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WATER FOR LIFE:
FUNDAMENTALS OF INEGRATED WATER RESOURCES MANAGEMENT

Sarajevo, 2011.

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Preface

Concern about the water is the task and responsibility of each individual. This means that each human being on planet Earth, no matter where he or she lives, shall give personal contribution to enable living conditions for future generations. All knowledge and understanding of water do not grant any right to humans on the Earth to unlimitedly use and pollute it. Water resources, enabling life on Earth and biological diversity available, oblige us to rational and careful use of water. Care and attitude towards the water should be both individual and collective. Each of us must take into account the consumption of water, the environment, whereby water makes a particularly important part of it, understanding that polluting the environment one is also polluting water. Each of us can make that little step and show good will and cultured attitude towards water and all those in need of it, which is actually every living creature, every community. We shall not forget that we are made water, and that taking care of water we take care of ourselves, our own children and generations to come.

Fresh water reserves are not an inexhaustible natural resource. Dynamic development of the society and the increasing pressures to the natural environment, and hence water, are becoming one of key issues of sustainable development, since the pollution of ground and surface water additionally impacts the reduction of water supplies. According to UN estimates, the Earth was populated with 1.65 billion people in the early 20th century, and by the end of the same century its population has increased to over 6 billion. UN predicts that in 2050 Earth will have around 9 billion inhabitants. However, the annual supply of renewable fresh water will remain almost the same. As noted by the UN Commission for Sustainable Development, the amount of water available to each person decreases as the population grows, raising the possibility of water shortage.

Although worldwide there are differences in attitude to water, everybody recognize its value and its central place in human lives nowadays. UN General Assembly at its 58th session passed a resolution proclaiming the period 2005-2015 as the International Decade for Action - Water for Life, in an effort that till 2015 proportion of people without access to healthy drinking water, as well as those who have no access to basic sanitation would be reduced to half.

This book is created as a result of the efforts that the issue of water management approaches all those who use water, who pollute water or those to whom water makes any kind of problems. Since everybody belongs to at least one of the three previously mentioned categories, our wish was that the book is informative and understandable to the widest possible audience. The book can also be used by experts dealing with water management, as well as managers and officers working in public institutions, both in water and other sectors associated with water use or water pollution. Book can also be used by professionals and activists in non-governmental organizations working on issues of water and environment protection, as well as professionals in companies that use and / or pollute water resources. One of the most important target groups are high school students and students in colleges, as well as their teachers. Students are a very important target group, since we believe that educating young population on water and environment we create conditions to achieve sustainable management of water resources in the near future.

Problems in water resources management are assessed within seven chapters of the book. The first chapter gives an overview of the basic characteristics of water, availability of water resources and processes of water circulation in nature, while the second chapter shows the importance of water for the environment and humans. By including these two chapters in the book concerning water management, our wish was to enable readers interested in these issues to become familiar with the basic characteristics of water before they engage in the study of certain aspects of water resources management. The third chapter presents the basic terms and concepts of the modern approach to water management, which is known as Integrated Water Resources Management. Chapter four provides an overview of the concept of sustainable use of water explaining various indicators of water consumption, and presents sustainable water consumption in different sectors. The main financial issues related to water use are presented in chapter five, while chapter six covers some of the most significant legal issues associated with water management. Chapter seven shows the socio-economic aspects of water use because water is the medium of fundamental importance to human life and health, being placed in the context of one of the fundamental human rights, the right to life.

Given the complexity and multidisciplinary nature of water management, this book presents only more important aspects related to this issue. This at any case does not mean that other issues not covered in this book do not have certain or even highest importance for establishing sustainable water resource management.

At the end of this preface, we would like to thank to all those who contributed to the publishing of this book. Special thanks go to Prof. Tarik Kupusovic and Prof. Hamid Custovic who carried out a review of this book and their valuable suggestions have contributed to its better quality.

Sarajevo, 2011.

Authors

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About Water

Water has always been a symbol of life to human beings. Water is a part of us and there is no human who can survive without it. A man can survive without water for around 8 days only, while it is considered that, without food, a man can survive surpassingly longer, up to 40 days.

Fresh water is a resource essential to all forms of human activities as well. Namely, starting from the primitive mankind development, a significant part of civilisation history is related to a constant tendency to use water resources, but also to protection from adverse water effects, especially flood protection. Civilisation development is most closely linked to the tendency to use water for irrigation purposes. It pertains to the cognition that water resources management represented a main factor in the development of the eldest civilisations in Euphrates, Tigris, Nile, and Indus Valley, that used such river water for irrigation and food production purposes.

Generally, humans have paid poor attention to rational use of water resources and their conservation throughout their development. It was the sudden increase in the number of Earth population uring the twentieth century that alerted the importance of water for life and humankind development.

One of the causes of such human behaviour is the ignorance about this resource and its features which make it significant for sustenance of life on Earth, but vulnerable and sensitive to different human being influences. Therefore, this chapter presents general characteristics of water, substantial for apprehension of its role in various natural, social and economic processes.

1.1 Available Water Resources

From the space perspective, the Earth looks like a blue planet. Water makes approximately 71% of our planet surface, with major part of it located on the south earth hemisphere. Approximately 1.370 million m^3 (Table 1.1) or 97,6% of total water quantity belongs to salt sea water (Wetzel, 1983). Only around 2,4% of water belongs to fresh water suitable for drinking purposes, irrigation in agricultural activities or industry. Major part of fresh water occurs as ice on poles, in glaciers or in the frozen soil (Figure 1.1). Next major part belongs to ground water. Water from rivers and lakes, from atmosphere, for surface of the earth and from human beings is negligible when compared to the amount of water on poles. Only a small portion of fresh water, around 0.3%, is available for drinking. If water stocks from the whole world could fit one bathtub, than the portion of water available for constant use throughout one year would hardly fill one teaspoon.

Table 1.1 Quantity of Water in Biosphere

Biosphere Components	Volume (1.000 km^3)	% of Total Quantity	Retention Period
Oceans	1,370,000	97.61	3,100 years
Polar ice, glaciers	29,000	2.08	16,000 years
Ground water	4,000	0.29	300 years
Fresh water lakes	125	0.009	1-100 years
Salt water lakes	104	0.008	10-1,000 years
Soil humidity	67	0.005	280 days
Rivers	1.2	0.00009	12-20 days
Atmosphere humidity	13	0,0009	9 days

(Source: Wetzel, 1983)

Available fresh water quantities are unevenly distributed on the Earth, as observed in Table 1.2. Average quantity of renewable water resources in the world, mostly comprised of the surface water course flow, is around 42,780 km^3/year (Shiklomanov, 2000). The largest water quantities are in Asia and South America, 13,510 and 12,030 km^3/year respectively, and the smallest in Australia with Oceania and in Europe (2,400 and 2,900 km^3/year respectively). These data do not illustrate the availability of water resources for population needs most precisely, therefore Table 1.2 outlines the value of index called Total Actual Renewable Water Resources (TARWR), which presents the amount of available renewable water resources per inhabitant annually, m^3/inhabitant/year (UNESCO, 2006).

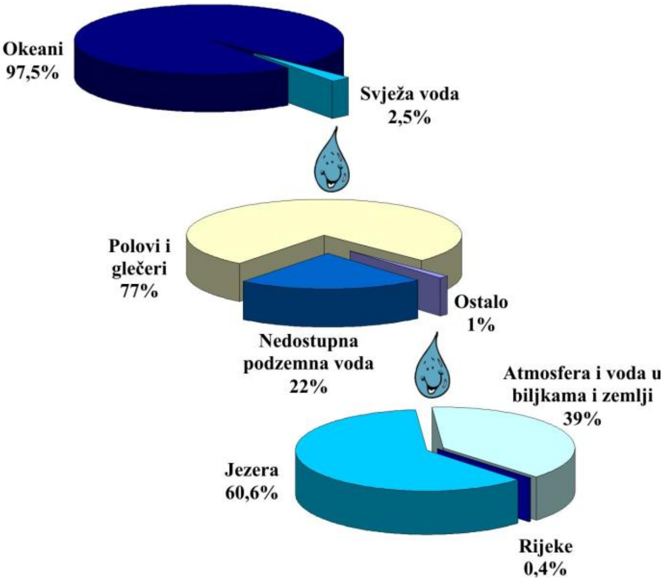

Figure 1.1 Distribution of Water Worldwide

Based on this index, average available water quantity, expressed as m^3/inh/year in the world is 7,600, with the highest available quantity in Australia and Oceania (83.700), and the lowest in Asia (3.920).

Table 1.2 Total Actual Renewable Water Resources Worldwide

Continent/Earth	Surface Area (10^6 km^3)	Population (million)	Water Resources (km^3/year)			TARWR (m^3/inh/year)
			Average	Max.	Min.	
Europe	10.46	685	2,900	3,410	2,254	4,230
North America	24.3	453	7,890	8,917	6,895	17,400
Africa	30.1	708	4,050	5,082	3,073	5,720
Asia	43.5	3.445	13,510	15,008	11,800	3,920
South America	17.9	315	12,030	14,350	10,320	38,200
Australia and Oceania	8.95	28,7	2,400	2,880	1,891	83,700
Total Worldwide	135	5.633	42,780	44,750	39,780	7,600

(Source: Shiklomanov, 2000)

It shall be noticed that TARWR index values change steadily following the constant increase in the number of population on the Earth. Growth trends between 1970 and 1994 led to the decrease of available water quantities in this period, from 12,900 to 7,600 m^3/inh/year (Shiklomanov, 2000), when the highest decrease was recorded in Africa (reduced by 2.8 times), Asia (by 2.0 times) and in South America (reduced by 1.7 times). Meanwhile, available quantity of renewable water resources per inhabitant in Europe decreased by 16% only.

It is assumed that the areas with available water quantity below 1,700 m^3 per inhabitant are exposed to the so-called "water stress" (Falkenmark and Widstrand, 1992), while areas with less than 1,000 m^3/inh/year are exposed to "extraordinary water stress". Based on the available data, approximately 41% of the world's population, or 2.3 billion people from 2000, lives in basins exposed to water stress (Revenga et al., 2000). 1.7 billion out of that number of population lives in basins exposed to extraordinary water stress. Based on the assessment for 2025, approximately 48% of population or 3.5 billion people worldwide will live in basins exposed to water stress.

Average quantity of renewable water resources in Bosnia and Herzegovina, expressed through the average runoff of surface waters, is equivalent to 1,155 m^3/s (Barbalić et al., 1994; ZZVS-ZZVM, 2010) or 36.4 km^3/year. Spatial and time distribution of such waters is very unequal. Thus, annual runoff from the Danube basin area is 22.77 km^3 (Figure 1.2), which makes approximately 62.5% of the total water runoff from the territory of Bosnia and Herzegovina, whereby the size of this basin area covers approximately 76% of the territory of BiH. Runoff from the remaining BiH territory is 13.66 km^3/year, directed towards Adriatic Sea.

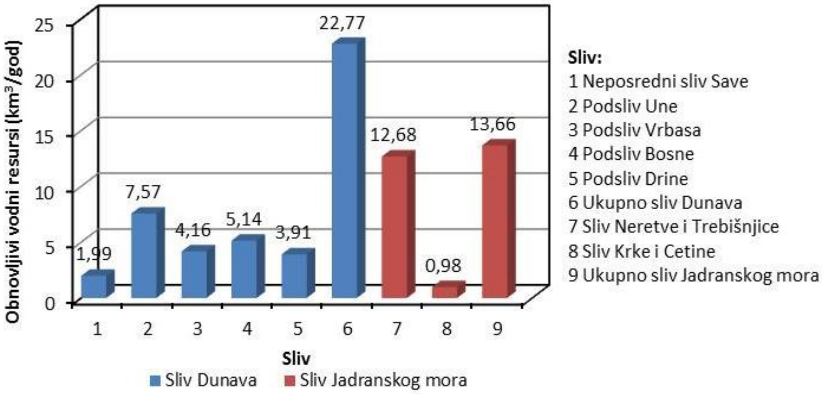

Figure 1.2 Total Renewable Water Resources in BiH

Spatial nonlinearity becomes even more expressed if individual sub-basins are observed (Figure 1.2). The largest renewable water resources are available within Neretva and Trebišnjica River basins (12.68 km^3/year), and the smallest within Krka and Cetina River basins (0.98 km^3/year).

However, the sitation is considerably different if available water resources per inhabitant are observed. The largest quantity of available water resources is within Neretva and Trebišnjica River basins, around 29,060 m^3/inh/year (Figure 1.3). The most endangered is the Bosna River basin, with the available water quantity of only 2,820 m^3/inh/year. It is the basin that covers 20.4% of the BiH territory, and encompassed approximately 40.2% of the population, whereby only around 14.1% of the available water resources runs off this surface area.

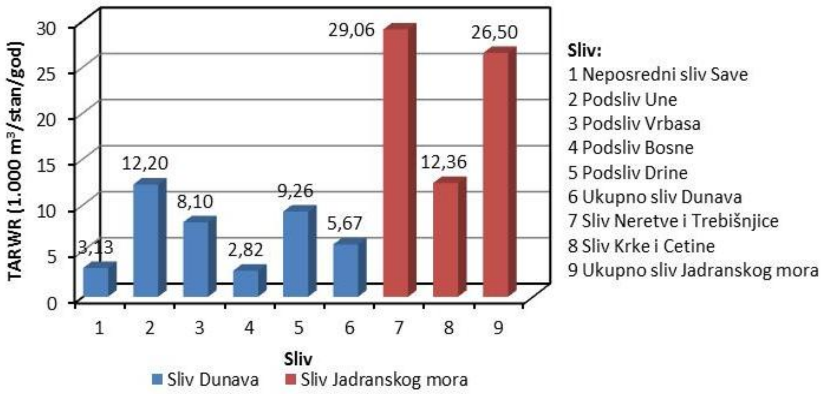

Figure 1.3 Total Renewable Water Resources in BiH per Inhabitant

Afore-mentioned indicators for certain BiH territories are even more adverse if time variability of available resources is considered. Namely, available water resources on the territory of BiH are considerably lower during dry years than the above indicated average values. Thus, for instance, every 40 years on average, quantity of available water resources falls to below 60% compared to above indicated average quantities (Barbalić et al., 1994), and once in two hundred years, available quantities fall below 40% than the average values.

1.2 Basic Characteristic of Water

Water is a very unusual mineral resource, with physical and chemical characteristics different to all other known compounds or substances. Thus, for instance, there is no substance which can be found in all three state of matters concurrently; gas, liquid and solid. Water has a very high boiling point, while ice has a very high melting point (Stumm and Morgan, 1996). The highest density of liquid water occurs at the temperature of 3.98°C, and not at the freezing point, thus water is expanded upon freezing. Water has a very surface tension, and represents and excellent solvent for numerous substances

Afore-mentioned characteristics of water are a consequence of the bipolar character of the water molecule (H_2O), consisting of two hydrogen and one oxygen atom (Stumm and Morgan, 1996) with the molecular weight of 18. This is the most common form of water in nature (99.7%), however, there are also other types of water made of hydrogen and oxygen isotopes, and thus the molecular weight of such water types is 19, 20, 21 and 22. Such, the so-called "heavy waters", have considerably different physical and chemical characteristics than common waters, but due to very low distribution of heavy waters in nature, only common water characteristics are presented herein.

1.2.1 Principal Physical and Chemical Characteristics of Water

Some of principal physical and chemical characteristics of water include:

- thermal capacity, boiling and melting point;
- dissolving capacity;
- density upon heating and cooling;
- surface tension.

Thermal capacity, boiling and melting point. Thermal capacity, representing the quantity of heat required to raise the temperature of the unit mass of water by 1°C, is very high for liquid water, 4.18 J/g/K (at 20°C). Actually, only several substances, such as liquid ammonia (5.14 J/g/K), liquid hydrogen (14.2 J/g/K) and lithium, have higher thermal capacity than water (Wetzel, 1983). Some other significant substances in the biosphere, including many types of rocks, have considerably lower thermal capacity, around 0.85 J/g/K. As a consequence of this characteristic, water heats and cools five times slower than earth. In order to heat 1 litre of water by 1°C, it is necessary to apply 3,300 times more energy than to heat the same volume of air.

Upon cooling, water releases heat. Upon water heating and cooling, its temperature slightly changes, thus, mild climate prevails in the areas with large quantities of accumulated water – for example coastal areas. Generally, consequently to this characteristic, water bodies such as lakes, seas and oceans are large accumulators of heat, with the stabilising effect on thermal regime and climate on the Earth.

Milder winters and higher precipitation are perceived in these areas if compared to the continental inside, providing water masses cool slower and release heat into the atmosphere slower than to the land (Wetzel, 1983).

Thermal capacity of ice at the temperature of 0°C is around 50% of the thermal capacity of liquid water and it reduces with the temperature reduction. However, water holds a large quantity of latent (hidden) heat, meaning heat required for transition of water from solid to liquid state, or from liquid to gas state. Transmission of one gram of ice to the liquid phase requires 333.4 J of heat, whereby water retains the temperature of 0°C. Latent heat of water evaporation is considerably higher and is equivalent to 2,258 J/g, and of water sublimation (transmission from solid directly to gas phase) even 2,840 J/g. Water releases heat upon the occurrence of ice. Therefore, upon transmission of 1 g of water to solid phase, the amount of heat released is sufficient to heat 250 l of air by 1°C. Due to afore-mentioned characteristics, large quantities of energy are needed to melt the snow in spring time.

Dissolving capacity. Water is an excellent solvent as various solid, liquid and gas substances are dissolved in it (Baird, 1995). There are absolutely no insoluble substances in nature, thus, all minerals contained in the soil dissolve in natural waters, including poorly dissolvable eruptive rocks, heavy metals, etc. Good solvability in water enables dissolution of gas and solid substances from the atmosphere within precipitation, whereby water serves as the recycler of the atmosphere. Otherwise, such substances would accumulate in the atmosphere, and thus adversely affect the living world. As a consequence of the ability of water to dissolve different substances, there is no absolutely pure water or water not containing any impurities in nature.

Density upon heating and cooling. Unlike other substances which reduce upon cooling and expand upon heating, such rule is not applicable to water. The highest density of pure water is 1 g/cm^3, and occurs at the temperature of 3.98°C (Wetzel, 1983). At lower and higher temperatures than the afore-mentioned, the density of water in liquid state reduces (Figure 1.4). The density of pure ice at 0°C is 0.9168 g/cm^3, which is approximately 8.5% lower than the density of pure water in liquid state at equivalent temperature (0.99987 g/cm^3).

Afore-mentioned differences in water density are rather minor, but significant for different processes in the nature. Therefore, for example, if water on the surface of a lake freezes in winter conditions, the density and temperature of the bottom water will increase, thus lakes never freeze in lower layers. It enables maintenance of life in water ecosystems during winter months as well. Furthermore, the difference in density of a water body, for example a lake, at different water column depths may result in the so-called thermal stratification of a lake. Stratification occurs as a consequence of high temperature gradient (°C/m) at certain depth within a lake, meaning major change of water temperature per one meter of water depth. Due to high temperature gradients, changes in the density of water within the related zone are large, thereby increasing the energy required for water mixing. In case of insufficient energy within the system to mix water layers of different density, thermal stratification occurs. It is considered that the cause of this phenomena in lakes is the temperature gradient of >1°C/m (Wetzel, 1983).

Water density is considerably affected by its composition, or the content of dissolved salts. The density approximately linearly increases with the increase in salt concentration (Wetzel, 1983). The density of sea water, with average content of salts of 35‰, is 1.02822 g/cm^3 at 4°C. Water salinity also changes the temperature at which the highest density and freezing point occur. Thus, the highest density of sea water (with the salinity of 35‰) occurs at the temperature of -3.52°C, with the freezing point of -1.91°C.

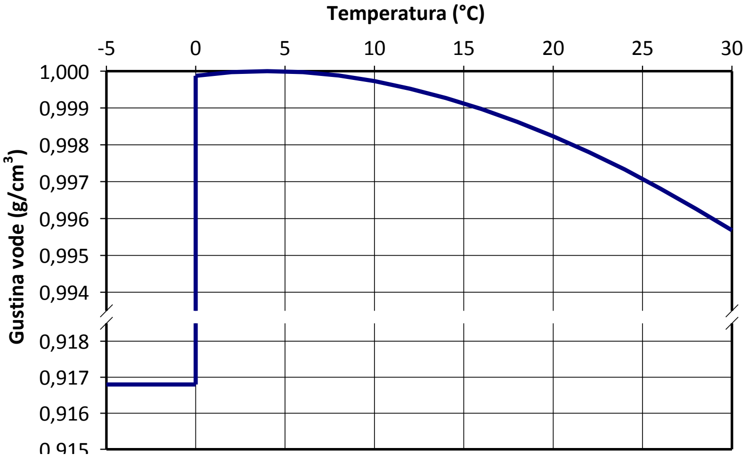

Figure 1.4 Change in Pure Water Density at Different Temperatures

Surface tension. At water-air interface, relations between molecules become unbalanced, resulting in the creation of an interface of liquid under tension. This characteristic enables life and movement of insects on water surface, while for some organisms, such surface film on water represents a habitat to which they adapted for living purposes. Surface tension causes capillary rising of water in small pores, as well as movement of water from deeper soil layers towards plant roots, delivering food and water required for their development.

Surface tension of pure water at air-water interface is higher than of any other liquid (0.749 mN/cm at 5°C), except mercury. Pure water surface tension considerably reduces with the increase in the content of organic substances, and depending on local conditions, it reaches values from 0 to 0.20 mN/cm.

1.2.2 Water Quality Indicators

The quality of fresh water ecosystems is variable, as many of human activity products inevitably end in water, while others released into air or soil eventually again end in water ecosystems. Determination of qualitative water characteristics is carried out for the purpose of defining the status of surface and ground water bodies, drinking water quality, quality of waste water discharged into the environment, etc.

Water quality is defined based on the examination of their physical, chemical and biological characteristics.

1.2.3 Physical Water Quality Indicators

Depending on the type of tested water, the tests most frequently include below listed physical parameters:

- temperature;
- colour, smell and taste of water;
- concentration of total solid, suspended and dissolved substances;
- water turbidity and transparency;
- electric conductivity.

Water temperature is a very important parameter as it affects the dynamics of many physical, chemical and biochemical processes. Generally, the increase in the temperature of water increases the velocity of certain chemical and biochemical reactions, and reduces the solubility of oxygen and some other gases (Jahić, 1990). Optimal temperature of drinking water is 8-12°C, and either increase or decrease of temperature in relation to the afore-mentioned results in the reduction of water potability. Water temperature has special importance for certain types of industrial waste waters that may develop high values of this parameter, even exceeding 30°C, as such high temperatures may affect the ecological status of their recipients.

Colour, smell and taste occur due to presence of different organic and anorganic elements and compounds in water: humic substances, mineral oils, sulphides, phenols, iron, and similar substances. Drinking water should not have any excplicit colour and smell, to be acceptable for consumption. The taste of water stems from minerals dissolved in water. In case of waste water, colour, smell and taste are important as indicators of the presence of different contaminating substances.

Total solid substances represent the remains following water evaporation. They may occur in form of suspended and dissolved substances. Suspended substances, by their specific weight, may be lighter or heavier than water. In the first case, such substances float on water surface, while in the latter case, they suspend in water or settle. In natural waters, suspension of substances partly occurs as a consequence of the removal of eroded soil substances from a river basin, either by means of natural erosion processes, or as a consequence of human activities, through point or diffuse source discharge. Effects of suspended substances to the environment are very diverse (Thornton et al., 1999), and among other things, include: (i) increase in water turbidity, (ii) reduction in penetration of light that may lead to reduction of biological productivity in water systems, (iii) possible destruction of natural habitats, (iv) suspended substances may be a base for absorption of nutrients, heavy metals and biocides, and can lead to increase or decrease in the availability of such substances to a phytoplankton, etc. Due to afore-mentioned effects, suspended substances are one of crucial quality indicators for natural and waste waters, and is principally always tested. Upon testing, it is particularly important to determine the share of mineral and organic substances as it, from many aspects, defines the treatment of sludge produced in the process of waste water treatment.

Water turbidity occurs due to presence of suspended and colloidal substances in water (Jahić, 1990). It is expressed in Nephelometric Turbidity Units (NTU). As afore-mentioned, increase in water turbidity leads to reduction of light penetration, limitating thus primary productivity of water plants. As photosynthetic organisms are at the bottom of the food chain in water ecosystems, this phenomenon may lead to significant impact on organisms at higher levels in the food chain (Novotny and Chesters, 1981). Water turbidity is not desireable either in drinking water or water used for technological needs of some industries (water in cooling systems, production of alcohol and nonalcohol beverages, etc.).

Electric conductivity, i.e. specific electric conductivity (μS/cm at 20°C) is a parameter which indicates the total quantity of substances dissolved in water, and is, therefore, very useful for water contamination assessment. However, electric conductivity does not always occur as a consequence of water contamination. High salinity water, e.g. sea water, also has high electric conductivity.

1.2.4 Chemical Water Quality Indicators

There is a large number of different anorganic and organic substances and parameters defining the quality of water. Examination of all chemical quality indicators is very rarely justified and feasible, due to technical impossibility to examine all parameters, and especially due to extremely high costs of such analyses. Therefore, in practive, the tests include only certain number of chemical parameters to provide an answer to water quality issue or to refer certain specific parameters for additional analysis.

Most frequently tested chemical water quality indicators include:

- pH water reaction, alkalinity and acidity;
- dissolved oxygen content;
- water hardness;
- chemical (COD) and biochemical (BOD) oxgen demand;
- content of macronutrients: different nitrogen forms (total nitrogen, ammonia, nitrates, nitrites, total nitrogen by Kjeldahlu) and phosphorus (total phosphorus, orthophosphates);
- heavy metals.

In natural and waste waters, in addition to above listed parameters and depending on the testing objective, analysis includes also the content of chloride, sulphate and sulphide, total oil and grease, mineral oils, detergents, phenols, cyanide, polychlorinated biphenyls (PCB), pesticides and other organic and anorganic compounds.

pH water reaction is one of basic indicators of the quality of natural and waste waters, It is expressed as a negative logarithm of the molar concentration of hydrogen ions in water, following the pattern below (Novotny and Chesters, 1981):

$$pH = -\log[H^+]$$

thus, it is used for determination of water acidity. Providing chemical characteristics of water, pH value may vary in the range pH = 0 –14. Acid waters are characterised by pH value of pH < 7, a alkaline by pH > 7, while in case of neutral water reaction, pH value is pH = 7. Natural waters in Bosnia and Herzegovina (BiH) mostly have mildly alkaline reaction, deriving from carbonates and bicarbonates which occur as the result of decomposition from limestone rocks. It is considered that water is of good quality when its pH value is within limits 6.5 – 9.5, which is a marginal value for drinking waters in BiH (BiH, 2010).

Alkalinity and acidity represent a measure of the buffer capacity of water, determined by addition (titrating) of certain quantity of acid and alkali (respectively) into water until target pH value is achieved.

Content of dissolved oxygen. Content of oxygen in natural waters is one of the most significant water quality indicators, as oxygen is crucial for metabolism of all aerobic water organisms (Wetzel, 1983). Oxygen reaches water through dissolution from the atmosphere, as well as by means of photosynthetic activity of water plants. Solubility of oxygen from atmosphere depends on temperature, air and water pressure, water salinity, etc. Temperature is a crucial factor as solubility considerably increases with the reduction of water temperature (Figure 1.5). Thus, at the temperature of 0°C oxygen solubility in pure water is 14.62 mg/l, at 20°C solubility is 9.09 mg/l, and at 40°C only 6.41 mg/l (Wetzel, 1983). Indicated concentrations mean saturation, or saturation of water with oxygen.

However, content of oxygen in natural waters very rarely corresponds to above mentioned concentrations. Content of oxygen is usually lower in relation to the concentration upon saturation, as a consequence of oxygen consumption for oxidation of different organic and anorganic compounds in water. Under certain conditions, it is possible that the content of oxygen in water exceeds the level of saturation, which a consequence of the phosynthetic activity of algae and other aquatic plants (Wetzel, 1983).

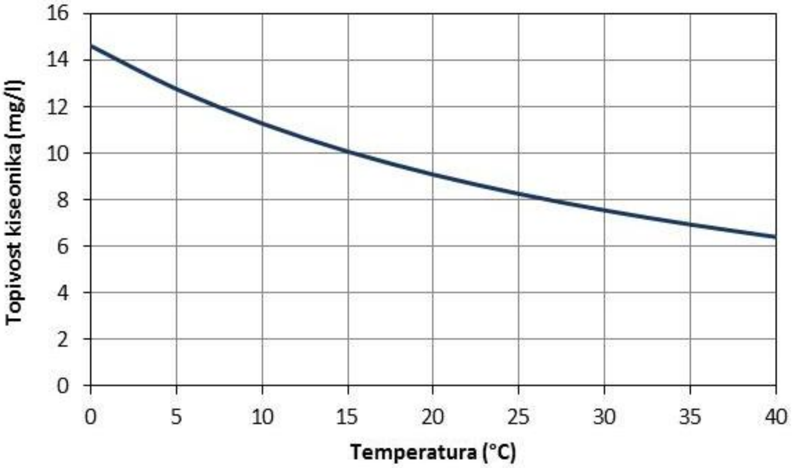

Figure 1.5 Solubility of Oxygen in Pure Water at Different Temperatures

Water hardness is defined by the content of calcium and magnesium salts (Wetzel, 1983). There is carbonate hardness, which is a consequence of the content of Ca^{2+} and Mg^{2+} ions bound in terms of carbonates and bicarbonates in water, and noncarbonate hardness, which derives from Ca^{2+} and Mg^{2+} ions in form of sulphates, chlorides and nitrates. Noncarbonate hardness is also called permanent hardness as it does not disappear by sedimentation due to water boiling, unlike the carbonate hardness. In BiH area, hardness is most frequently expressed in mg of $CaCO_3$/l or in German hadness degrees (°dH), applying the following conversionn coefficient (Wetzel, 1983):

$$1°dH = 17.90 \text{ mg } CaCO_3/l$$

Hardness gives specific taste to drinking water. Most pleasant for drinking is water of medium hardness (8-12°dH), while soft water is tasteless (Mutschmann and Stimmelmayr, 1999). Waters of high hardness are, except for drinking, unsuitable for many indusrial processes, especially if water is used in cooling systems.

COD and BOD. Different organic substances are present in natural and waste waters. Due to a large number of organic substances, their direct determination is very complex, and in most cases extremely expensive. Therefore, the content of organic substances is determined indirectly, by means of defining chemical and biochemical oxygen demand for their oxidation.

In case of Chemical Oxygen Demand (COD), the content of organic substances is determined by use of a strong oxidation agent, calcium-dichromate ($K_2Cr_2O_7$), in very acid environment and at boiling temperature. It shall be notices herein that not all organic substances react to the oxidation agent (Stumm and Morgan, 1996). Anyhow, it is considered that this method is used to define oxygen equivalent of organic substances ”totally” present in water.

In natural and waste waters, it is particularly important to determine the share of organic substances which subject to mineralisation by means of microbiological dissolving processes. Namely, biologically soluble substances are a threat to natural waters, as the solution of these substances by use of oxygen existing in water occurs in natural conditions. Biochemical Oxygen Demand (BOD) is determined by means of measuring oxygen demanded by microorganisms for oxidation of organic substances in normal conditions (20±0,5°C, sufficient content of oxygen and microorganisms). Maintenance of normal testing conditions is very important as the velocity of microbiological oxidation process largely depends on these factors. Microbiological oxidation of organic substances is a relatively long process, and depending on temperature, it can last from around 10 to over 30 days. As long period of time is needed for one analysis, it has been adopted by the convention to carry out the analysis of biochemical oxygen demand after 5 days, marked as BOD_5. Oxygen demand for organic substance oxidation after five days is lower than the oxygen demand for a complete oxidation (BOD_{pot}), or $BOD_5 < BOD_{pot}$.

Providing microorganisms can oxidate only a part of organic substance contained in water, and not the other part contained in form of complex organic compounds, the following relation is applicable at all times:

$$BOD_5 < BOD_{pot} < COD$$

Content of macronutrients. Nitrogen and phosphorus are biogenic elements contained in living substances and many organic and anorganic compounds (Ćerić et al., 2003). Plants consume them in large aquantities, which is why they are called macronutrients. If nitrogen and phosphorus are discharged to natural waters in larger quantities, the process of eutrophication may occur. Eutrophication is a process of recharge of water with nutrients, resulting in the increased primary production, or production of water plants (Ćerić et al., 2003).

Nitrogen occurs in water in multiple valent forms, as ammonium (NH_4^+), nitrate (NO_3^-), nitrite (NO_2^-) and organic nitrogen. Ammonium is usually considered the indicator of fresh fecal contamination, but increased concentrations may also be a consequence of applying fertilizers to surfaces alongside the water body, as well as a consequence of organic substance degradation. Nitrites and nitrates arise from the process of nitrification, a process of microbiological ammonium oxidation. Therefore, the content of nitrites and nitrates is often related to older fecal contamination or an older contact of water with organic substances.

Phosphorus occurs in water most frequently in form of orthophosphates (PO_4^{3-}). Phosphorus is the most frequently limiting nutrient in water ecosystems (Wetzel, 1983; Ćerić et al., 2003), or nutrient contained in the smallest quantity compared to other elements and compounds water plants need for their growth and development. Therefore, the control of the content of phosphorus forms in natural and waste waters is of particular importance.

Heavy metals. Although some heavy metals, such as iron, manganese, cadmium, copper, zinc, boron, cobalt, molybdenum and vanadium, have important biological role in the growth of plants and many animals (Wetzel, 1983), heavy metals are considered dangerous and hazardous in natural and waste waters. In certain concentrations, heavy metals are toxic to living organisms. Although the level of toxicity depends on the type of organism and some other factors, it can generally be stated that marginal toxicity values for all heavy metals are very low; for example, level of toxicity for Cd and Hg is 10^{-8} M, for Cu 10^{-7} M, for Ni, Pb and Zn 10^{-6} M, and likewise (Novotny and Chesters, 1981). Particularly dangerous are heavy metals which have the ability to bioaccumulate in living organisms. An example of such heavy metal is mercury, which bioaccumulates in an organic form and biomagnifies in the food chain, and thus can lead to central nervous system damagees and other health problems (Baird, 1995).

1.2.5 Biological Water Quality Indicators

Commonly tested indicators of the biological quality of surface and waste waters include:

- microbiological water composition;
- hydrobiological water quality.

Microbiological water composition. Large number of waste waters, including communal waste waters and industrial sanitary waste waters, contain bacteriological pollution. This pollution, regardless of whether waste waters are treated or not, at the end reaches natural waters. Due to its human health dimension, content of bacteria and other microorganisms in water is the most important sanitary-hygienic water quality indicator.

Different microorganisms may be contained in natural and waste waters - bacteria, viruses, protosoes. However, microbiological testing mostly encompases only certain indicator microorganisms that indicate the occurrence of pollution, and sometimes its source as well (U.S. EPA, 1978). Coliform bacteria are used as indicator microorganisms; however, they are not specific indicators of fecal pollution (Fewtrell and Bartram, 2001). Therefore, in addition to total coliform baceria, thermotolerant colifroms are tested as well – fecal colifrom bacteria (typical representative *Escherichia coli – E. coli*), fecal origin streptococci and enterococci (*Enterococcus*), as well as sulfite-reducing clostridia (*Clostridium perfringens*). Presence of coliform bacteria and fecal origin bacteria in drinking water is not allowed (BiH, 2010).

Hydrobiological methods. Analyses of physically-chemical and microbiological composition of water are very useful indicators of the current status of a water body, but do not illustrate a long-term picture concerning status of the observed system. Therefore, different hydrobiological water characterisation methods are applied for assessment of the long-term status of a water body, including diversity indices, biotic indices, saprobiotic methods, habitat quality assessments, and other (Knoben et al., 1995).

During the last hundred years, three types of indices for water quality assessment have prevaled in Europe (Metcalfe, 1989): saprobic indices, diversity indices and biotic indices. Indices from afore-mentioned groups commonly applied in Bosnia and Herzegovina include:

- Shannon-Weaver Diversity Index (Shannon and Weaver, 1948) is used for initial assessment of ecosystem quality. The index is based on the number of macroinvertebrate species present in the ecosystem and the one species individuals in the sample. Depending on the index value (H), water quality is classified into four categories: pure water (H > 3), slightly polluted water (H = 2-3), medium polluted water (H = 1-2) and heavily polluted water (H < 1).

- Pantle-Buck Saprobic Index (Pantle and Buck, 1955) is determined on the basis of a relative frequency of the detected species and saprobic value of species, or tolerance to pollution. The quality of water is expressed through seven classes (Liebmann, 1962), presented in table 1.3.
- Extended Biotic Index (Ghetti, 1986) determined based on the fact that water body pollution causes disappearance of macroinvertebrates in the following order: *Plecoptera*, *Ephemeroptera*, *Trichoptera*, *Gammarus*, *Asellus*, *Chironomidae/Oligochaeta*. Based on the calculated value of the Extended Biotic Index, water is grouped into five classes: pure water (EBI > 10), slightly polluted water (EBI = 8-9), medium polluted water (EBI = 6-7), polluted water (EBI = 4-5) and heavily polluted water (EBI < 4).

1.3 Hydrological Cycle

Water on the Earth is always in movement beyond, on and below the earth surface (Figure 1.6). Such constant process of circulation, renewal and apparent loss of water on the Earth is called hydrological cycle, known also as the cycle of water circulation in nature. Such movement of water in nature has existed for billions of years and the overall life on the Earth depends on it.

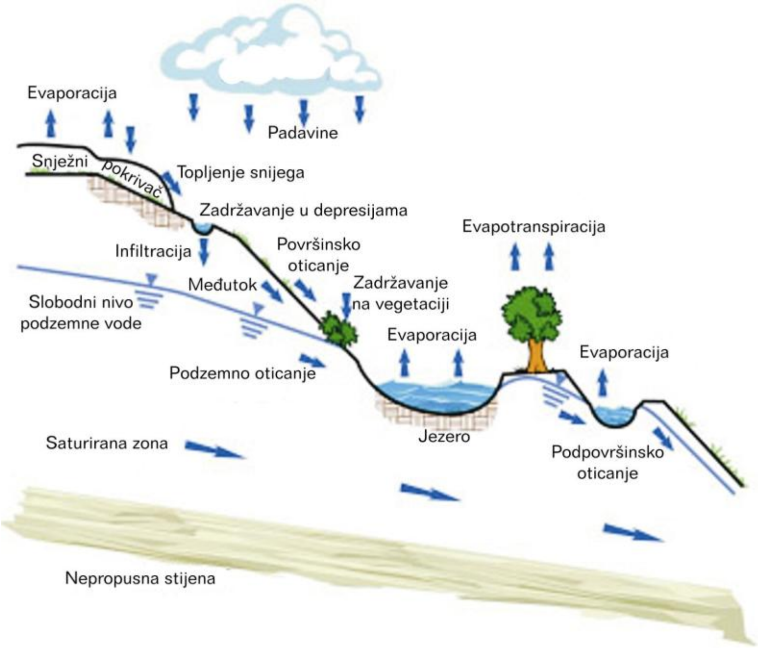

Figure 1.6 Water Circulation in Nature (Source: Ćerić et al., 2003)

Main components of the hydrological cycle that define movement of water in nature include (Thornton et al., 1999; Ćerić et al., 2003): (1) precipitation, (2) vegetation retention, (3) evapotranspiration, (4) infiltration, (5) surface runoff, (6) percolation and (7) ground runoff and accumulation.

Table 1.3 Water Quality Classes per Saprobity Index

Degree of Water Saprobity	Saprobity Index	Water Quality Class	Degree of Water Pollution
Oligosaprobic	1.00-1.50	I	Unpolluted to very slightly polluted
Oligo- to betamezosaprobic	1.51-1.80	I-II	Slightly polluted
Betamezosaprobic	1.81-2.30	II	Moderately polluted
Beta- to alfamezosaprobic	2.31-2.70	II-III	Medium polluted
Alfamezosaprobic	2.71-3.20	III	Medium polluted to polluted
Alfa- to polisaprobic	3.21-3.50	III-IV	Polluted
Polisaprobic	3.51-4.00	IV	Highly polluted

(Source: Liebmann, 1962)

1.3.1 Precipitation

Precipitation emerge from water steam found in the atmosphere, as a consequence of evaporation from earth.

The very evolution of precipitation is related to water steam condensation or sublimation, following excessive saturation of air with water steam. Highly important for water steam condensation is also the presence of aerocolloids in the air, very fine particles that serve as hygroscopic condensation core (Srebrenović, 1986). Aerocolloids are gas molecules or small parts of a solid substance, created through combustion of substances on earth, or small parts of certain pollution from earth.

Precipitation arises in different forms, as rain, snow, hail, frost, and dew. The quantity of precipitation is presented in the sum amount, as height of the column of water (in mm) that falls to the earth's surface within a unit of time.

There is approximately 13,000 km^3 of water in the earth's atmosphere (UNESCO, 2006), but the quantity of water that reaches the atmosphere throughout the year is considerably higher and is approximately 525,000 km^3 (Shiklomanov and Rodda, 2003). This quantity of water is very unevenly distributed through precipitation to individual countries worldwide. Thus, the quantity of precipitation in the countries from arid regions is approximately 100 mm (litters per m^2) annually, and in the countries from tropic and mountain regions the quantity of precipitation reaches up to 3,400 mm annually (Mitchell et al., 2002).

Precipitation are physically unevenly distributed in Bosnia and Herzegovina as well. Average annual quantity of precipitation in BiH is around 1,250 l/m^2, with Posavina region as the poorest in precipitation, with approximately 700-800 l/m^2 per year (ZZVS-ZZVM, 2010). The area characterized by its maritime climate, and mostly covering Herzegovina, is the area with the highest annual precipitation, reaching 1,000-1,500 l/m^2.

Time distribution of precipitation throughout the year is very unbalanced in BiH. Thus, for example, on the territory of Herzegovina, the quantity of monthly precipitation in summer months (July and August) is only around 30 l/m^2, while during spring and autumn months it exceeds 150 l/m^2 per month. Time nonlinearity is referred to by the data on average number of rainy days for the overall BiH which is around 130 or 35% of days per year (Ćerić et al., 2003).

1.3.2 Retention on Vegetation

Prior to reaching the ground, part of precipitation may retain on vegetation. Such part of precipitation is partly absorbed by a plant, and partly returned to atmosphere through the process of evaporation (Novotny, 1995).

Retained quantity of precipitation depends on: (i) plant species, (ii) age and density of vegetation, (iii) season and (iv) precipitation distribution and intensity (Thornton et al., 1999). In addition to vegetation structure, characteristics of the precipitation also have considerable effect on the retained quantity. In case of low rains, retention is higher, than in case of strong showers. Time distribution of precipitation within the year affects retention, thus, prolonged rains occurring several times a year have a small degree of retention, compared to short-term intermittent showers.

Retention losses may be significant. Based on the rough estimate for regions with moderate climate, retention on vegetation may be 20-60% of the total annual precipitation (Thornton et al., 1999). In literature, there are expressions for calculation of the quantity of water retained on vegetation, but they contain factors and parameters with values difficult to be determined for each subject area. Therefore, the retention degree is most precisely determined by means of direct on-site measurements.

1.3.3 Evapotranspiration

Evapotranspiration is a combined effect of the vaporisation of water from humid surfaces, called evaporation, and discharge of water into the atmosphere via plants as part of their living cycle, representing transpiration (Ćerić et al., 2003). As it is difficult to conduct separate measurement of evaporation and transpiration on site, measures are usually jointly expressed as evapotranspiration.

Evaporation is the process of vaporisation of water from earth or water surface, carried out under the effect of solar energy (Thornton et al., 1999). Evaporation intensity depends on numerous factors, such as air and water temperature, atmosphere pressure, air humidity, wind effects, vegetation, and similar factors. Characteristics of the land-plant-water system largely affect the intensity of evaporation, as a tree, a tree top and plant leaves: (i) are surfaces from which water evaporates, (ii) use their shadow to protect the land from the loss of humidity (iii) affect the quantity of humidity that air can take off the plant.

Transpiration is the loss of water through a plant, as a consequence of its metabolism, but mostly depending on the quantity of available heat. Transpiration is a very important ecological process, for: (i) the transport of nutrients and water into upper parts of plants and (ii) cooling of leaves. Level of moisture a plant can take from soil depends on the root system, as well as soil features and humidity. Only a small part of water needed to the plant is retained in its tissue, while major part of it evaporates into the atmosphere through leaves and other organs of the plant. The level of transpiration depends on evaporation power of air, i.e. partly depends on air temperature, wind, percentage of the saturation of air with moisture and the quantity of light (Ćerić et al., 2003).

Evapotranspiration intensity is conditioned by climate features of certain area, thus, it is very unevenly physically distributed on the Earth (Table 1.4). The most intensive evapotranspiration is in arid (dry) areas, where it is equivalent to almost around 70% of total precipitation, while in moderate climate areas the percentage is considerably lower (around 33%). Due to substantially higher precipitation in moderate climate areas, the total quantity of moisture that evapotranspirates into the atmosphere is the highest in these areas and the lowest in arid areas (Table 1.4).

Table 1.4 Distribution of Precipitation to Main Hydrological Cycle Components per Climate Zones

Hydrological Cycle Component	Moderate Climate		Semi-arid Climate		Arid Climate	
	(%)	(mm)	(%)	(mm)	(%)	(mm)
Total precipitation	100	500-1.500	100	200-500	100	0-200
Evapotranspiration	≈33.3	165-500	≈50	100-250	≈70	0-140
Percolation	≈33.3	165-500	≈20	40-100	≈1	0-2
Surface runoff	≈33.3	165-500	≈30	60-150	≈29	0-60

(Source: UNESCO, 2006)

In Bosnia and Herzegovina, there are no reliable data on the intensity of evapotranspiration. Some assessment carried out by means of empirical methods indicate that actual evapotranspiration varies from 390 mm (Čemerno) to 610 mm (Mostar) annually (Barbalić et al., 1994), which is within the frame of assessment presented in table 1.4 for moderate climate areas.

1.3.4 Infiltration

Part of precipitation that does not return to the atmosphere through the process of evaporation is subject to surface runoff or infiltration into the ground. Infiltration is a vertical movement of water from the surface into the soil (Novotny, 2003). In the circulation of water in nature, a part of infiltrated water again returns to the atmosphere through the process of transpiration. Remaining part of infiltrated water is retained in the soil or percolates through the soil to ground water.

Infiltration is a complex process affected by many factors, especially soil texture and structure, content of organic substance in soil, soil humidity, vegetation cover, temperature and other factors (Thornton et al., 1999). Therefore, infiltration capacity of the same soil may substantially differ in different ecosystems.

The largest infiltration occurs in case of precipitation on the intact vegetation cover and forest land (Ćerić et al., 2003). Generally, it can be stated that the degree of infiltration is higher if the coverage of the area with forest vegetation is larger. Important factor that affect infiltration in these habitats is the thickness of the bottom forest cover made of leaves and boughs, providing soil protection. As long as the protective bottom forest cover is undisrupted, forestry activities (attenuation, cutting, forestation, etc.) have generally minor impact on the level of infiltration. However, use of machinery and execution of substantial forestry activities may endanger such forest cover and reduce the permeability of forest soil, and thus reduce infiltration and increase surface runoff.

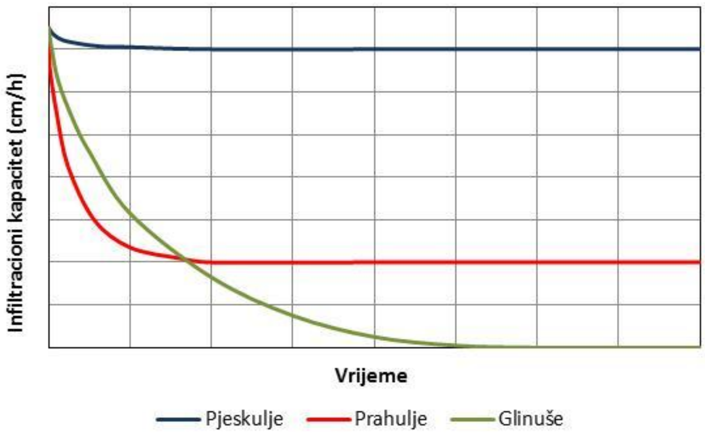

Figure 1.7 Typical Infiltration Curves for Soils of Different Texture Features

Plant root system, especially pores in the soil created after the decay, have significant impact on the intensity of infiltration into the soil. For example, vegetation with overgrwoing roots is usually more important for the increase of infiltration than the simple root plants. Large population of animals with pits in the soil, as well as insects and their maggots, may also increase infiltration on large surfaces. Another factor that significantly affects infiltration is the level of compactness of surface soil. For example, cultivated fields compacted by means of agricultural machinery may have considerably lower infiltration than forest surfaces. Exchange of plant species within certain area also has substantial impact on the capacity of infiltration.

Infiltration velocity reduces with time proximate to the law of exponents, as a consequence of gravitation and capillary forces managing the process. Characteristic infiltration curves for all three soil texture types are presented on figure 1.7 – sand soils, dust soils, and clay soils (Novotny, 2003). Infiltration, starting from high initial level, reduces very fast in the beginning, and then slower until it reaches a constant level, making the so-called infiltration soil capacity, f_c.

In case of sand soils, the degree of infiltration slightly changes with time as water is poorly retained in such soils, due to prevailing effects of the gravitation force. Sand soils generally have high infiltration capacity. However, in case of clay soils, pore space between soil substances fills with water during certain period of time, causing thereby very strong capillary forces due to small pore size. In case of such soil types, infiltration capacity is approximately equivalent to zero (Figure 1.7).

1.3.5 Surface Runoff

Water available for surface runoff is predominantly made of the part of precipitation: (i) not lost through the process of evapotranspiration and (ii) not infiltrated through the surface ground layer (Ćerić et al., 2003). Surface runoff occurs when the quantity of precipitation exceeds the infiltration capacity of soil and the capacity of he so-called „depression accumulations“ (Figure 1.8). Namely, the surface of the earth consists of smaller or larger dents and depressions fed with water until their volume is filled. Thereafter, surface runoff occurs.

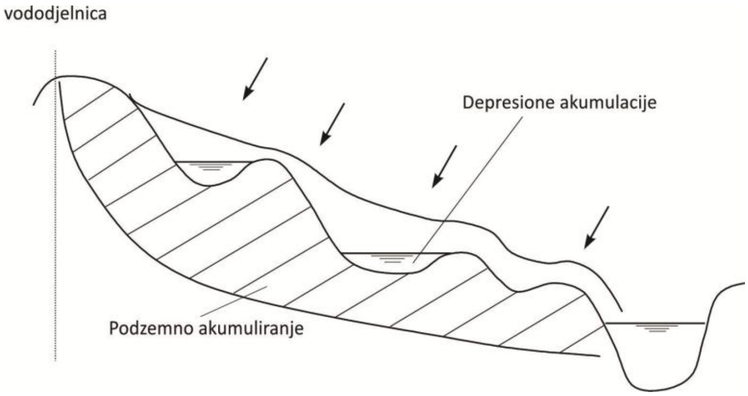

Figure 1.8 Schematic Overview of Surface Runoff (Source: Srebrenović, 1986)

Reaction of the flow to precipitation is commonly presented in terms of runoff hydrograph, whose typical form is shown on figure 1.9. Occurrence of precipitation in the basin opens the period of flow increase that lasts until the runoff inflection point. After that, the period of head flow starts and lasts from the inflection point in the increasing part of the curve until the same point in the decreasing part of the runoff curve. The top of the hydrograph or maximum flow rate appears within that period, in the moment when the overall basin district participates in the contact formation. Basically, that moment defines the so-called time of basin concentration.

The period of decrease includes the remaining part of the hydrograph (Figure 1.9). It can, but not obligatorily, fall to zero flow, depending on the retention basin capacity.

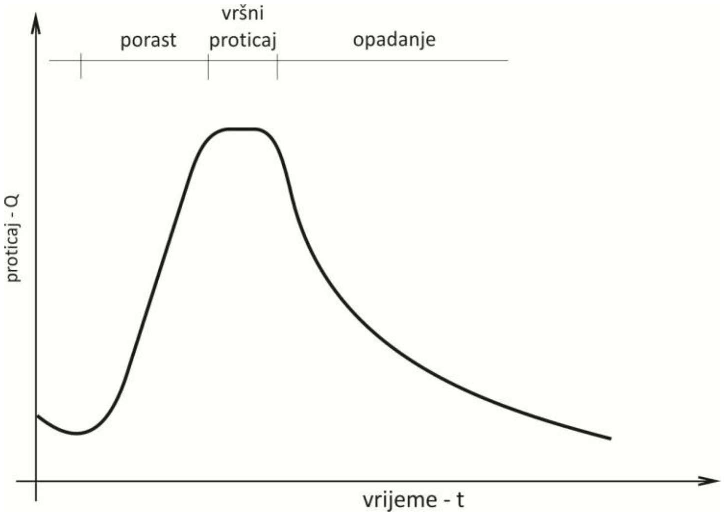

Figure 1.9   Typical Form of Runoff Hydrograph

Relation between the quantity of precipitation and surface runoff is usually accompanied by the dependence presented in bold line on figure 1.10.

If the overall quantity of precipitation was transformed to surface runoff, the dependence would be as presented in dotted line on figure 1.10 with the inclination of 45°. However, initial precipitation are retained in depression accumulations and infiltrate into the soil, thus the runoff does not start immediately after the start of precipitation. Runoff intensity gradually increases during precipitation with the increase of the content of water in soil and decrease of infiltration.

Surface runoff decreases with the increase of infiltration in the basin, capacity of depression accumulations and retention on vegetation, which is equivalent to the progress of dependence towards right as presented on figure 1.10. The quantity of surface runoff is also substantially affected by the basin humidity prior to precipitation, i.e. previous humidity. If the basin is very dry, major part of water that falls to the ground will be retained in depressions and dry soil. Therefore, the intensity of surface runoff will be low. In contrast, in case of a wet ground, there isn't much room for additional water in depression accumulations, thus the major part of precipitation will be subject to surface runoff. In that case, the dependence curve progresses towards left, as presented on figure 1.10.

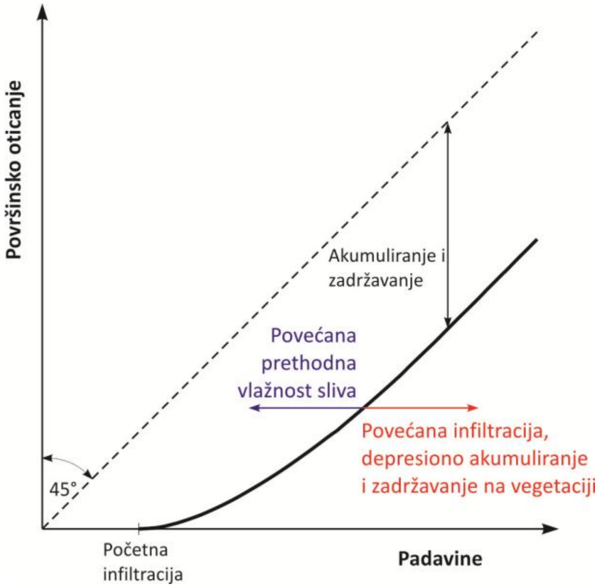

Figure 1.10 Typical Dependence of Surface Runoff on Precipitation Quantity

1.3.6 Percolation

Percolation is gravity drainage of water from the ground through the aeration zone to ground water (Ćerić et al., 2003). Only one part of the total quantity of water that infiltrates into the soil percolates to ground water. Remaining part is retained in the soil by means of different mechanisms, or absorbed by plants through their root systems. Namely, the soil consists of solid substances with pores of different dimensions. Infiltrated water is retained in pores by means of capillary forces or negative pore pressure, counter-proportional to pore dimensions. Water from the largest pores within the soil is easily drained, providing low pore pressure. Stronger capillary forces of smaller pores resist to gravitation and thus are more slowly drained (if drained at all). Large quantity of such water is available to plants and can be spent on evapotranspiration. In such conditions, soil humidity will be preserved only in case of very small pores.

Mechanisms for retention and movement of water in the soil are very complex and may be conceptually introduced by means of a model presented in figure 1.11 illustrating the relation between soil humidity and: (i) saturation point, (ii) field water capacity, (iii) withering point (Ćerić et al., 2003). Upon saturation, all soil pores are filled with water and percolation is at maximum. Percolation progresses ever until the field water capacity of the referred soil is reached, whereby capillary forces retaining water drops are in balance with gravitation forces. Following this point, there is no further percolation, i.e. gravitation water runoff, but the loss of water from the soil continues as plants use their roots to take moisture from the soil. At withering point, water in the soil is so strongly bound that no root can take it for its needs anymore. It is the quantity of water in the soil at which the plant starts to wither.

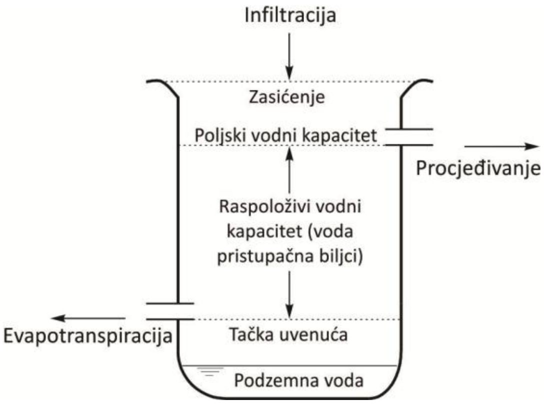

Figure 1.11 Conceptual Model of Water Movement and Retention in Soil (Source: Thornton et al., 1999)

These soil humidity parameters are primarily conditioned by the soil texture, and, at smaller extent, by means of cultivation and content of organic substances. Based on table 1.5, indicating soil humidity parameters for different texture classes, it can be seen that light (coarse grained) soils have substantially lower field water capacity than heavy (clay) soils. Therefore, percolation in coarse-grained soils is considerably higher than in heavy soils.

Percolation depends also on seasonal variations of infiltration and evapotranspiration. During wet and cold period of the year, percolation is more frequent, as a consequence of increased humidity caused by low evapotranspiration and/or high infiltration (Thornton et al., 1999). Generally, percolation is much lower during the remaining part of the year, primarily due to the necessity of infiltration to compensate the moisture lost in the process of evapotranspiration.

1.3.7 Ground Runoff and Accumulation

Water that percolates through the soil reaches the so-called “saturated zone” within the soil with pores fully filled with water and water being under pressure higher or equal to the atmosphere pressure (Novotny, 2003). Water in the saturated zone is mostly in movement, and only in exceptional cases it stands, or does not run. Water runs in the saturated zone under the effect of gravitation, from areas with higher ground water level to areas with lower ground water level.

Table 1.5 Soil Moisture Parameters (cm/cm) for Different Texture Classes

Soil Texture Class	Texture Sign	Saturation	Field Water Capacity	Withering Point	Percolation
Sand soil	P	0.44	0.09	0.03	0.35
Loam sand soil	IP	0.44	0.13	0.06	0.31
Sand loam soil	PI	0.45	0.21	0.10	0.24
Loam soil	I	0.46	0.27	0.12	0.19
Dust loam soil	PrI	0.50	0.33	0.13	0.17
Sand-clay loam soil	PGI	0.40	0.26	0.15	0.14
Clay loam soil	GI	0.46	0.32	0.20	0.14
Dust-clay loam soil	PrGI	0.47	0.37	0.21	0.10
Sand clay soil	PG	0.43	0.34	0.24	0.09
Dust clay soil	PrG	0.48	0.39	0.25	0.09
Clay soil	G	0.48	0.40	0.27	0.08

(Source: Thornton et al., 1999)

Geological formations saturated with water, containing substantial quantities of water for use and exploitation, are called aquifers (Todd, 1980). On the territory of Bosnia and Herzegovina, two main types of aquifers are found in: (i) rock masses characterised by intergranular porosity and (ii) carbonate rocks usually characterised by the so-called fissured cavernous porosity (Ćerić et al., 2003).

Intergranular porosity aquifers are dominantly made of free and at smaller extent poorly related clastites, and mostly of quaternary age (Ćerić et al., 2003). Based on the lithological composition, they are mostly made of gravels, sands and clays, in different interrelations. Aquifers may be very complex, with several mutually separated water horizons, different thickness, different structure of materials, and different hydraulic water flow mechanisms. In case of such aquifers, pores between substances of materials are saturated with water and ground water flows just through this porous space.

Karst aquifers appear in areas predominantly made of limestone and/or dolomite rocks. Unlike intergranular environments, the so-called fissured and cavernous porosity, which occur as the result of physical and chemical processes, prevail in karst. Namely, cracks and caverns in karst emerge due to structural and tectonic factors, and dissolving effects of water lead to their increase with time. Such aquifers are characterised by numerous surface and ground karst phenomena, irregular ground water circulation paths and cracked (unbound) ground water accumulations. Unlike intergranular environments, karst is featured by existence of concentrated ground water flows, often fast, and existence of zone watersheds that change their position depending on hydrological circumstances. Providing aforementioned characteristics of fissured and cavernous porosity, it can be said that karst aquifers are explicitly inhomogeneous and anisotropic.

2

Importance of Water for Environment and Human Beings

Water has a central role in integration of atmosphere, lithosphere and biosphere. It intermediates in global processes, transferring substances and facilitating chemical reactions. Water is not important from the aspect of protection of life and health of all living beings on the Planet only but its chemical characteristics enable man to use it for food production, energy production, transport, and as a resource or secondary resource in an array of industrial processes.

Approach to adequate good quality water is essential for human health; productive fresh water ecosystems are crucial for survival of many plant and animal communities, and clean or unpolluted water ecosystems provide an array of services to people all around the world.

Sustenance of the quality of water ecosystems is related to protection of human welfare, directly depending on protection of integrity and «medical status» of water ecosystems providing them food and other products required for living.

This chapter gives a brief overview of key concepts nedded to understand correlation between water, development, health and environment.

2.1 Water as Part of the Environment

Environment is defined as a set of external factors affecting human beings. Such external factors, known as environmental factors as well, derive from living and non-living nature of the proximate surrounding and thus are divided to (Raven and Berg, 2005):

- abiotic environmental factors representing non-living chemical and physical impacts of environment to organisms (sun light, light intensity, precipitation, temperature, wind velocity and direction, water availability, ground texture, salts, toxic substances, etc.);
- biotic environmental factors representing interrelation between living organisms in a living community, as well as human function (manufacturers, consumers and decomposers).

Environmental factors are integrated into a whole, as they condition and change each other and thus jointly, as a complex, affect human beings. Organisms adapt to such changes in their attempt to survive.

In consideration of the role and importance of environmental factors, it is difficult to say which one is the most important. However, the attempt to assess them would result in water on the first place, together with oxygen, carbon and nitrogen.

Importance of water, as main condition for survival of human beings, is multiple and far-reaching. Water is present on the Earth more than any other substance. Ripl (2003) calls water "biosphere circulatory system" as by circulating it defines the sustainability of life, has a number of significant functions and, among other things, represents:

- a „resource " in the process of photosynthesis;
- transport mechanism for different substances needed to people, animals and plants;
- decomposer for all nutritious elements needed to feed living organisms;
- important climate factor due to evaporation and condensation process, as well as relatively high thermal capacity;
- habitat for many plant and animal species.

Impact of water to human beings is determined by the available quantity and quality of water (Hogan and Monosson, 2010).

Apart from the importance of water input into the ecosystem through precipitation or condensation, water availability essentially defines which plants and animals will locally adapt to living conditions of certain habitat. Generally, availability of water for living world needs is observed through a hydrological cycle and its components (Chapter 1.3.), while, on functional level, crucial role is assigned to mechanisms for absorption of water for the living world needs, as well as the way of accumulation and opportune availability of sufficient water quantities.

On the other side, importance of water availability goes side by side with its quality determined by physically-chemical and biological composition. It does not refer to the concentration of substances naturally present in water ecosystems, but also to substances occurring as the result of artificial human input. Essential substances absorbed from water by plants and animals are micro and macro nutrients (nitrogen, phosphorus and potassium) and minerals (zinc, magnesium and iron) crucial for metabolitic functions (Barker and Pilbeam, 2007). Each substance, if artificially introduced in concentrations above naturally present concentrations, is considered a polluter disrupting natural balance and disabling life protection. Besides, water contaminated by contagious and parasite disease agents, represents a path for transmission of disease causes (Jusupović, 2008).

2.2 Importance of Water Dependent Ecosystems

2.2.1 Water Ecosystems

Basic natural organisational unit spatially and timely unifying all living beings and their non-living environment by energy flow and matter cycle is called ecosystem (Raven and Berg, 2005). Ecosystems are roughly divided into land and water ecosystems.

In a broader sense, water ecosystems imply all habitats, natural or changed by humans, with water as crucial environmental factor, regardless of whether it refers to water (aquatic) habitats with water as a living environment, or those (the so-called semi aquatic) in which water (at least periodically) dominantly modifies other environmental factors within an ecosystem, or actively participates in modelling the ecosystem character, its structure and function.

Water ecosystems are divided to two groups: fresh water ecosystems and sea and ocean ecosystems.

Fresh water ecosystems distinct either by the state of matter (liquid, solid, gas) or by location (ground and surface waters) or as standing or stagnant waters. Standing waters are divided to: sources, streams (standing waters with smaller water flow compared to rivers) and rivers (standing waters with river bed width exceeding 5 meters). Stagnant waters are divided to: pools (shallow pits filled with water and regularly subject to drying during dry periods); wetlands / swamps (featured by low pH value, low salt concentration and abundant organic substances); marshes (this type of land water is featured by water mass shallowness, developed water plants as sun streams reach marsh bottom); lakes (in principle, it is possible to distinct two layers of water: upper lighted layer – euphotic, thus it represents the productive part of the lake – trophogens, lower and deeper non-lighted layer – aphotic, which is non-productive – tropholytic).

Figure 2.1 Boračko Lake

Ecosystems of seas and oceans cover 2/3 of the Earth's surface and represent the largest oxygen providers due to phytoplankton which lives on the sea water surface and releases twice as much oxygen than plants on land (Rach, 2004). If sea is considered a living space, it consists of two elements: sea bottom and sea water. Unlike land waters, all seas and oceans are interrelated and develop continuous water space. It provides sea organisms with a broad movement scope, with temperature, salinity and depth as major restrictions to their expansion.

As already presented in Table 1.1, available quantity of fresh waters when compared to sea water, as well as their distribution is negligible. While land and sea ecosystems have higher percentage of known species, fresh water ecosystems have larger relative abundance of species (Table 2.1). There are approximately 100.000 of known fresh water animal species worldwide. Around 40% of known fish species (10.000 out of known 25.000 species) are settled in fresh waters. The number of fish species per water volume is more than 5.000 times higher in fresh than in salt waters (UN/WWAP, 2003; Millennium Ecosystem Assessment, 2005).

Table 2.1 Relative Abundance of Species in Freshwater, Sea and Land Ecosystems (Relation between Abundance of Species and Occupied Surface Area)

Ecosystem	Occupied Surface Area (% in relation to total earth's surface area)	Abundance of Species (% in relation to the number of known species)*	Relative Abundance of Species
Freshwater	0,8	2,4	3,0
Sea	70,8	14,7	0,2
Land	28,4	77,5	2,7

* does not sum to 100% as the overview excludes 5,3% of known symbiotic species
(Source: Millennium Ecosystem Assessment, 2005)

2.2.2 Water Ecosystem Services

Certain components of water ecosystems can be considered from economic aspect as «goods», and the results of functional processes within the ecosystem as «services». **Ecosystem functions** are defined as ecological processes and components within an ecosystem producing benefits, directly enjoyed by humans and supporting economic activity. **Ecosystem services** are ecosystem functions actively or passively, consciously or unconsciously used, consumed or enjoyed by human beings (Gomez-Baggethun and De Groot, 2010). Ecosystem services may encompass material goods (e.g. water and resources) as well as different non-commercial, or "free", services (climate regulation, waste assimilation, water treatment, erosion control, flood mitigation, etc.).

Millennium assessment of ecosystems conducted in 2005 (Millennium Ecosystem Assessment, 2005) divides water ecosystem services to:

- providing services: food, drinking water;
- regulating services: climate regulation, flood regulation;
- support services: land creation, nutrients recycling;
- cultural services: spirituality, aesthetics, education, recreation.

Some examples of services and functions which give the dimension to water ecosystems are presented in Table 2.2.

Providing **drinking water and food** are two crucial services which water ecosystems provided to human beings and which are significant for human welfare.

Main source of renewable drinking water for human consumption derives from land water ecosystems, including lakes, rivers, wetlands and ground aquifers. It is estimated that around 1,5-3 billion of people depends on ground water as a source of drinking water. In order to increase the availability of drinking waters, dams are constructed, and it is estimated that they currently accumulate 6.000-7.000 km^3 of water (Millennium Ecosystem Assessment, 2005).

Table 2.2 Examples of Ecosystem Services and Functions

Ecosystem Service	Ecosystem Function	Example
Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climate processes on global or local level	Regulation of greenhouse gasses, fixation of carbon dioxide
Water regime regulation	Hydrological regime regulation	Providing water for agriculture (irrigation), industrial processes or transport
Water supply	Water accumulation and retention	Intake of water from river streams, accumulations and aquifers
Nutrient recycling	Accumulation, internal recycling, processing and piling of nutrients	Nitrogen fixation, cycling of N, P and other nutrients in nature
Waste treatment	Return of mobile nutrients and removal or degradation of surplus nutrients and compounds	Waste treatment, contamination control, detoxification
Food production	The part of net primary production used as food	Fishing including mussels, Cray fish, and other edible river and sea organisms
Resources	The part of net primary production used as resource	Biomass production (reed).
Recreation	Providing the possibility to pursue recreational activities	Eco-tourism, sport fishing and other sport activities
Cultural dimension	Providing the possibility for non-commercial use	Aesthetic, art, educational, spiritual and/or scientific values of water ecosystems

(Izvor: adopted from Constanza et al., 1997)

Fish yield is of high significance in the developing countries. In certain communities, fish is a primary source of animal proteins, while commercial or sport fishing substantially contributes to the development of local and national economy. For example, 35-45 million of people pursues sport fishing in USA and in total spend 24-37 billion of US$ per year (Millennium Ecosystem Assessment, 2005). Apart from these obvious functions for human health and welfare, fish offers other benefits as well, e.g. in pharmaceutical industry where certain substances from fish are used for research purposes, as potential ingredients of certain medicine or for mitigation of parasite disease transmission such as malaria and shistosomiasis (Holmlund and Hammer, 1999).

Other water ecosystem services closely related to human welfare include:

- ***Water treatment and waste detoxification.*** Water ecosystems, especially wetlands, play crucial role in treatment or reduction of toxic features from different waste substances. It is claimed that wetlands reduce concentration of nitrates for over 80% (Zodler, 2003).
- ***Climate regulation.*** One of important roles of water ecosystems is regulation of global climate changes through retention or release of the major part of fixed carbon in biosphere. For example, it is estimated that peatlands, although they cover only around 3-4% of the earth's area, retain 540 gigatons of carbon, which is around 1,5% of total estimated carbon stocks and around 25-30% of carbon retained in land vegetation and soil (Millennium Ecosystem Assessment, 2005).
- ***Mitigation of climate changes.*** Increase of the sea level and sudden changes in the frequency of storm occurrence related to climate changes may result in erosion of beaches and habitats, increased salinity of estuaries and freshwater aquifers, changes in tides, changes in sediment and transport of nutrients, and frequent beach floods. Water ecosystems, such as mangrove[1] and flooding areas, may have major role in physical mitigation of climate change impacts (Mayers et al., 2009).
- ***Culture.*** Water ecosystems provide significant aesthetic, educational, cultural and spiritual services, as well as an array of possibilities for recreation and tourism development. Economic value of coral reefs, calculated on the basis of revenues from tourism and recreation activities, is estimated to around 29,8 billion of US$ per year (Cesar et al., 2003).

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[1] Forest vegetation of tropical and subtropical areas covering estuaries, ebb and tide zone, lagoons and protected bays.

2.2.3 Assessment of Water Ecosystem Values

Assessment of the value of certain (water) ecosystem is an extremely complex problem. While for some other services, e.g. biomass production, it is easy to determine the economic value, the value of some other service, e.g. climate regulation, is almost impossible. Some authors even state that it is not possible or wise to assess ecosystem services as how to assign certain value to "non-material" assets such as human life, aesthetic environment appearance or long-term ecological benefits (Straton, 2006).

Assessment of ecosystem service values is reduced to determination of how relatively small changes in the quality or quantity of the service affect human welfare, or ecosystem benefits people achieve through their activities or price of ecosystem "goods". Thereby, some of such impacts may be assessed through the establishment of market mechanisms while others are not subject to such assessment. For example, coral reef represents a fish habitat. The value of such water ecosystem is in increase and concentrated fish yield. Each change in the quality and quantity of the ecosystem would adversely affect fish yield which would be felt on the fish market and which allows economic evaluation. On the other side, coral reef also has an important role in recreational diving as well as biodiversity conservation that do not have their market value.

Constanza et al. (1997) tried to determine the value of 17 different services of the world's ecosystem[2] for 16 biomes[3]. They assessed the value based on the unit surface area of biomes, multiplied it with the total surface area of each biome, summed all services and biomes, and calculated that annual value (mostly non-market) for the overall biosphere is equivalent to 16-54 trillion (10^{12}) US$ or in average 33 trillion of US$ per year. Out of such value, the value of water ecosystems is estimated to 27,5 billion of US$ per year, with 21 billion of US$ for sea ecosystems, 4,8 billion of US$ for wetlands and 1,7 billion of US$ for lakes/rivers. For comparing purposes, global annual national gross product is equivalent to 18

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[2] Evaluated services include: gas regulation, climate regulation, disorder regulation, water regulation, water supply, erosion control and sediment retention, soil formation, nutrient recycling, waste treatment, pollination, biological control, refuge, food production, resources, genetic resources, recreation, culture.

[3] Biome is a major climate- and geographically defined territory or aquatory, encompassing similar ecosystems and areas where ecosystems are related by means of more complex raltions of action, reaction, coaction and food change and where substance cycling and energy flow occur at high rates.

trillion of US$. Due to high estimation insecurity, given values are considered minimum values.

2.3 Pollution of Water Dependent Ecosystems

2.3.1 Ecosystem Elasticity

Key feature of an ecosystem resulting from the link between the structure and function is its elasticity (Holling, 2001). Elasticity refers to the capacity of ecosystem to sustain shocks and, at the same time, maintain basic structure and functionality. It means that the ecosystem performs self organisation to adapt to obstructions and changes. If the pressure exceeds certain tolerance margins, ecosystem can wade to the so-called alternative stable condition with much lower capacity to provide the desired service. If the pressure continues, ecosystem may fully cease to provide the desired service (e.g. water contamination which will disable use of water for recreational purposes).

Preservation of services provided by water ecosystem depends on the continuous presence of main environmental components (e.g. water, key fish communities, communities within the sediment, marginal vegetation) and uninterrupted processes within the ecosystem (e.g. water retention, elimination of polluters, nutrients and energy recycling); therefore, it depends on the «medical condition» of the ecosystem. There are three main benefits of the preservation of good condition of ecosystems (De Groot et al., 2010), as follows:

- Environmental dimension (value) of water ecosystem mostly refers to interrelation between ecosystem components, e.g. the value of certain tree in the control of erosion that may affect the quality of water or the value of one species for survival of the other or survival of the overall ecosystem.
- Economic dimension as men use many ecosystem functions (water, resources, food, etc.) to achieve economic benefit and secure welfare.
- Socio-cultural dimension where biodiversity and natural water ecosystems represent crucial source of non-material welfare affecting mental health and historical, ethical, religious, and spiritual values supported by such ecosystems.

2.3.2 Pressures to Water Ecosystems

At the beginning of the 21st century, the world faced the crisis of insufficient good quality drinking water. It has been proved that the destruction of freshwater ecosystems occurs much faster and at larger scale than in case of sea or land ecosystems, and the status of freshwater plant and animal species is more endangered than the species from other ecosystems (Millennium Ecosystem Assessment, 2005). Accelerated processes of water habitats and living world destruction are caused, among others, by (UN/WWAP, 2003; Mayers et al., 2009):

- Growth of the world population which inevitably affects increased demands for drinking water intake and thus endangers all functions of ecosystems including habitat, production and regulatory functions.
- Construction of infrastructure facilities such as dams, embankments, regulations affecting habitat integrity, causing changes in flow, water temperature, transport of nutrients and sediment, as well as closing of migration paths, and thus endangers the quality and quantity of water, habitats, existence of flooding areas, fishing zone, etc.
- Change of land allocation e.g. drying of wetland areas that eliminates key components of water ecosystems, loses functions, integrity, habitats and biodiversity, changes the mechanisms of surface flow and natural loading of water systems. Filling by deposits occurs, inevitably endangering functions of natural flood control, fish and wetland bird habitats, recreational functions, water supply, water quantity and quality, etc.
- Excess fishing and exploitation leading to excess use of resources, and loss of ecosystem functions and biodiversity (reduction of the ground water level, collapse of fishing resources).
- Input of exotic species which, throughout their struggle to survive, compete with other existing species and thus affect the loss of production and nutrient recycling, and cause the loss of autochthonous species endangering production function of ecosystems, habitat and recreational function of ecosystems.
- Discharge of waste water that change chemical and biological water composition:
    - discharge of communal waste water which in most cases is considerably organically loaded;
    - discharge of industrial waste water which may contain detergents, oils, heavy metals and salts, oil, thermal pollution, nutrients, etc.;
    - percolation from agricultural surfaces and cattle farms which use large amounts of pesticides, herbicides, and chemical fertilizers with expressed contents of nitrates and phosphates that cause eutrophication once they reach water;

- disposal of solid waste into water streams which, depending on the chemical composition of the disposed waste, may contaminate water with organic and inorganic pollution.

2.3.3 Water Ecosystem Contamination Consequences

Control of chemical and biological contamination is crucial for preservation of water ecosystems. Many human activities, starting from water supply, through transport, mining, and chemical industry, have the potential to contaminate water. Thereby, water contamination may be defined as any change of physical, chemical or biological water characteristics that make it useless for use in its natural state (Kaushik and Kaushik, 2010).

Impacts of different polluters on water ecosystem integrity are presented in Table 2.3.

Table 2.3 Impact of Polluters on Water Ecosystems

Type of Polluter	Impact
Organic Substance	Addition of large amount of organic substances reduces the availability of dissolved oxygen in water consumed by micro organisms that need oxygen for degradation of organic substance. The lack of dissolved oxygen adversely affects animal species, especially fish. Deoxygenation facilitates release of phosphates from sediments and causes eutrophication.
Nutrients	Addition of large amount of substances containing nitrogen and phosphorus facilitates the growth of algae and other plants that consume oxygen from water upon their degradation. Their produce bad smelling gases under anaerobic conditions. Excess growth or degradation of plant material will change CO_2 concentration that further affects the change of pH water value. Change of pH value, oxygen concentration and temperature will affect the change of many physically-chemical characteristics of water.
Pathogens	Many types of waste, especially sanitary-faecal waste waters, contain pathogens and non-pathogenic micro organisms and viruses that cause diseases such as cholera, dysentery, typhus, hepatitis, etc.
Toxic Compounds	Polluters such as heavy metals, pesticides, cyanide, and other organic and inorganic compounds are not biodegradable, are resistant and hazardous for aquatic organisms. Non-degradable toxic substances may biomagnify and result in toxic impact at different levels within the food chain.

(Source: Kaushik and Kaushik, 2010)

Aquatic organisms are fully in contact with potential contamination, and through gill breathing they filter enormous quantity of water and thus relatively non-selectively adopt all bio available substances. Adopted substances are retained in the adipose tissue and their concentration increases with time. This process is called **bioaccumulation.** Transmission of substances from organisms at a lower trophic level, where large number of individuals accumulated toxic substances, to organisms on higher trophic levels is called **biomagnification** as the concentration of such toxic substances increases with the progressing through the food chain. Thereby, dangerous substances may reach human food as well, leaving serious consequences for human health (Kaushik and Kaushik, 2010). Examples of bio-magnification of the most known insecticide, dichlorine-diphenyl-trichloroethane (DDT), in water ecosystem is given in Table 2.4.

Table 2.4 Biomagnification of Dichlorine-Diphenyl-Trichloroethane (DDT) Compounds

Component within Food Chain	DDT Concentration (ppm)
Water	0,000001
Zooplankton	0,01
Minnow	0,1
Needles	1
Birds	10

(Source: Kaushik and Kaushik, 2010)

Consequences of the contamination of water ecosystems are multiple, as each contaminating substance has different effects on different groups of organisms. The scope of the problem of water ecosystem contamination can also be demonstrated through the analysis of the impact of bio accumulated polluters to human health. Heavy metals such as mercury, cadmium and lean can be taken as an example as they cause a spectrum of different diseases following acute or chronic exposure to increased concentrations.

Mercury, which finds its way to water bodies under the influence of microbiological activity, transforms to methyl mercury, the most poisoned organic form of mercury which 100% absorbs within the organism. Methyl mercury biomagnifies; on top of the food chain, the largest predator fish may contain from 10.000 to 100.000 times higher concentration of methyl mercury in their body than in water or sea itself. First mercury poisoning cases were recognised with consumers of fish contaminated with methyl mercury in a small Japanese town Minamata. Furthermore, in winter in 1971/72, one of the largest poisoning was recorded in Iraq when wheat, treated with fungicide (based on mercury) for prevention of fungal infections, was used in nutrition. Mercury destroys central nervous system, and the disorder scale depends on the duration of poison exposure. Due to industrial purposes, mercury has become so present in the environment that it can (in traces) be recorded in diverse sea food (mussels, fish and Cray fish), including tuna fish (Jusupović, 2003; Vitale, 2011)

The largest quantities of **cadmium** emerge in metal industry. Through the food chain, cadmium is accumulated in plants, animals, and humans. High concentrations are present in animal entrails, vegetables and edible mushrooms. Approximately 85% of cadmium reaches human body through ingredients and around 15% through water. Breathing absorbs very small quantity of cadmium with high toxic dimension due to their carcinogenic effect. Based on animal experiments, it is known that cadmium has embriotoxic, teratogenic and carcinogenic effects. Excessive chronic cadmium load causes the syndrome called Itai-Itai, described for the first time in the frame of chronic endemic mass disease in Japan in 1955 when large quantities of cadmium from local concern waste waters entered the system for irrigation of rice plantations. The syndrome has the following symptoms: anaemia, apathy, osteomalacia with crank pains and skeleton malformations, enteropathy and liver and kidney damages (Nakagawa et al., 1990; Orhanović, 2003).

Figure 2.2 Caulerpa alexis – Green Tropic Algae
(Source: http://public.carnet.hr/dps-zagreb/images/AlgaSTHV.jpg)

Lead is a heavy metal used nowadays in large number of industries as an important ingredient of different substances in batteries, paints, anti-corrosion agents, petrol, and is present in waste waters produces during such processes. It can reach drinking water if water supply system is made of lead pipes. Lead poisoning occurs only after input of small quantities of lead into the organism for a long period of time. It vary rarely occur as acute poisoning in case of the input of large quantities. Lead is accumulated in the organism, mostly in bones, where it stays throughout entire life. Lead poisoning affects kidneys, liver, brain and central nervous system. Furthermore, it causes anaemia and mental retardation with children (Knežević, 2003).

Apart from freshwater ecosystems, attention shall also be paid to coastal seas, particularly endangered by inflow of rivers from the land which carry large amount of waste substances, pesticides, heavy metal salts and detergents. In addition, one of the largest sea water polluters on the global plan are boats which discharge polluters, most frequently oil. The data on the presence of new species talk about major changes in the quality of sea water, as new species in the absence of a natural predator expand very fast and further contaminate sea ecosystems. The largest danger in that sense is green tropic algae *(Caulerpa taxifolia),* which conquers Mediterranean Sea very fast and increases its trophication (Figure 2.2). This alga expands in the Adriatic Sea very fast as well.

3

Basis of Integrated Water Resources Management

Water is one of the most important resources on the Earth as it regulates human population growth, and considerably affects population health and living conditions as well as the state of biodiversity (Newson, 1992). Throughout history, people used water to satisfy different needs, attempted to control water quantity and quality or to protect themselves against water where it presented a danger to population or property. Crucial civilisations came into existence and developed alongside large watercourses, or on areas comprising significant water resources (Biswas, 1997). Such civilisations developed advanced technological knowledge on water management, which was a significant assumption for their sustenance.

Industrial revolution that occurred end of the 18th and beginning of the 19th century led to a rapid development in this field, accompanied by technological advancement and advancement of water management science and knowledge. During the 19th century and in the first half of the 20th century, economic development in many countries was very strong and fast, often pursued at cost of acceptable and sound water management. Pollution was considered an inevitable consequence of the development, or the price that had to be paid if economic progress wanted to be achieved (Heathcote, 1998). Environmental awareness began to emerge in the world as late as 1960's, primarily as a consequence of numerous excessive pollutions that occurred beforehand (Ćerić et al., 2003). It resulted in the introduction of legislation on water and environment protection, firstly in the most developed countries as the first and most polluted countries. In addition, new institutions for monitoring and solution of problems related to the pollution and use of water were introduced. In that period, water resources management was directed towards engineering planning of water use, water protection and protection against water, as well as construction of different structures to facilitate execution of above mentioned water management functions.

During the last decades it was noticed that water-related problems could not be solved anymore only by engaging water experts, nor pertaining institutions. Namely, water-related problems are more and more associated to other issues and sectors within a state, for example to social, economic, environmental, legal, and political issues at different government levels, and often have an international dimension (Biswas, 2008). Therefore, contemporary water resources management requires knowledge and approaches often above pure engineering approaches, and outside a single scientific field. Existing situation and current trends indicate that water-related problems in future will become more and more complex, and more associated to other economic sectors, such as agriculture, energy, industry, transport and communications, as well as social sectors, such as education, health, rural and regional development (ADB, 2007).

Recognising the problems above, the United Nations (UN) organised in 1977 a conference on water in Mar del Plata, in Argentina, considered by many authors as a milestone in water management approach (e.g. Lee, 1992). The importance of this conference is comprised in the fact that a global problem of the failure of water management policies that existed in that time to achieve target management objectives was recognised (Heathcote, 1998). International conference on waters and environment, organised in Dublin (Ireland) in 1992 is another important event that led to the change in the water management approach, following which Integrated Water Resources Management (IWRM) has become a more frequent topic. This approach is presented in the continuation of this chapter in more details.

3.1 Basic Definitions and Concepts

Although there is no unique definition of Integrated Water Resources Management, the definition of Global Water Partnership – GWP is often used, which defines IWRM as a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP, 2004). This approach to integrated management provides management and development of water resources in a balanced and sustainable way, taking into account social, economic and environmental factors and interests.

Although water resources management policy is established at different government levels – state, entity, cantonal (provincial), urban, etc., planning and organisation of management in accordance with IWRM concept is carried out at river basin level, i.e. river basin district. River basin is an area or part of land from which all water finally reaches certain observed point within a watercourse (Figure 3.1).

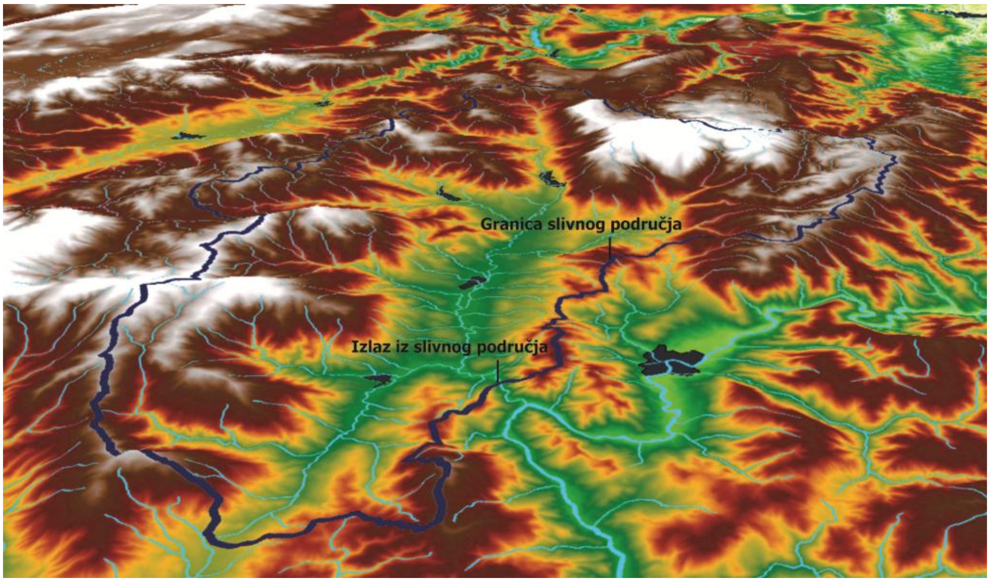

Figure 3.1 River Basin District

As a landscape within which different hydrologic processes are carried out in nature, basin district represents logical and practical spatial unit for water management. Management approach at the basin level enables settlement of conflicts between different stakeholders within the frame of a unique hydrologic system, often impossible at the level of administrative management units encompassing only parts of individual basins.

Below listed activities deriving from the main objectives of the integrated water resources management shall be jointly defined just at river basin levels:

- rational use of water resources;
- planning and management of water resources based on scientific and professional basis;
- avoiding conflicts among stakeholders;

- considerable participation of stakeholders and the population in the process of planning and management;
- reinforcement of institutional, financial and other mechanisms.

3.1.1 Water Conflicts and Stakeholders

Conflict may generally be defined as a disagreement upon execution of appropriate activities in certain situation (Grigg, 1996).

Conflicts in water sector occur as water freely moves in time and space, regardless of political and ownership borders, leading to disputes among different users, water polluters and other stakeholders. Conflicts are constantly present, since individuals and groups have different comprehension of the water value, different priorities, interests and future expectations.

Conflicts occur between and within different groups representing stakeholders in terms of management of water resources within a river basin district, such as (Heathcote, 1998):

- Government bodies, state institutions and enterprises, authorised for enactment of legislation and decisions on water resources management, monitoring of use and protection of waters and implementation of other water management activities. This group encompasses also other institution associated to water sector, e.g. institutions from the sector of tourism, agriculture, industry, including hydro-energetics, etc.
- Industrial consumers, interested mostly in provision of water in quantity and quality required to meet their technological, sanitary and other needs.
- Population in the largest number of cases represents the most numerous group of stakeholders. As a group, population is most interested in quantities, quality and price of water they consume. This group is the most complex in terms of expressing views and collecting relevant information on water resources management.
- Non-governmental organisations (NGO) represent a significant factor in public consultations on water resources management, especially in the developed democratic countries. However, it is important to know that, very often, attitudes of these organisations do not reflect fully or at all attitudes of major part of the public on certain water management issues (Heathcote, 1998).

It shall be stressed that conflicts do not occur among previously mentioned groups only, but also among members of a single group. Thereby, conflicts may arise among state institutions with different priorities in terms of water management; for example, institutions in the forestry sector interested in forest cultivation and cutting may be slightly or not interested for protection of watercourses and sources (Figure 3.2).

A conflict among stakeholders within groups often arise due to the fact that water flows to each one of us from another upstream area (“someone else’s” water), just as we send “our” water to someone else located downstream. This conflict among sides located upstream and downstream arises very frequently.

Figure 3.2 Conflicts between Forest Cutting and Source Protection

Conflicts do not arise only among neighbours within a community, but also among communities within a state, as well as among states and regions, whereby we speak about the so-called transboundary water conflicts. Areas with the most serious water conflicts are those facing the lack of water. Rivers flowing through different countries, such as Jordan, Tigris, Euphrates, Nile, but also Rhine, Danube, and Sava are starting to be a source of economic conflicts.

Transboundary conflicts are particularly important as there are 263 transboundary river basins and hundreds of transboundary ground water aquifers worldwide (GWP-INBO, 2009). Transboundary river basins make approximately 45% of the Earth’s land surface, comprising around 60% of the world’s population.

The problem referring to the lack of water currently affects numerous communities in the world, leading to impossibility of their sustenance and future development, prosperity and well being, and thus international stability. Growing disparity in distribution of water also leads to international tensions and conflicts.

Final conflict is a war conflict. Lately, it is constantly being stated that wars in the world will arise due to the lack of water. Historical studies indicate the hypothesis based on which conflicts concerning water often lead to a war. Certainly, a war conflict greatly contributes to tensions between Israel and Palestine, Iraq and Syria, India and Pakistan, and many other countries.

3.1.2 Term „Integrated“ in Water Resources Management

The term integration in water resources management is very complex as it includes several different aspects of natural resources and water demands management. Therefore, integration may be considered from the aspect of two main categories (GWP, 2004):

- natural system, defined by water availability and quality;
- social system, or human factor impact, defined by use of water resources, wastewater production and contamination of water resources.

Integrated water resources management includes a multidisciplinary approach to the settlement of the problem based on different scientific disciplines: natural sciences, including mathematics, technology, law, politics, sociology, etc. Integration of different disciplines enables comprehensive review and settlement of problems within a river basin.

Regardless of separate analysis of natural and social systems given below, integration occurs not only within but also between such two categories or systems.

3.1.3 Natural System Integration

Concerning natural system, integration is carried out at several levels.

One of the most important aspects is the integration of landscape and water resources management, i.e. space. Providing hydrological cycle, i.e. water movements, depends on water-landscape-air-vegetation system, management of the overall landscape, and not only water, is of crucial importance for integrated water resources management. As water is one of key factors defining character and well-being of all ecosystems, IWRM implies consideration of all environmental components with a river basin district, meaning integration of environmental issues into water resources management.

Management at the river basin level is significant not only as an instrument of integration of spatial and water resources management, but as a facilitator in identifying and resolving conflicts of interest between upstream and downstream water consumers and polluters. The knowledge on the vulnerability of downstream parts of the system to upstream activities, including for example excessive water consumption that reduces available quantities of water downstream, discharge of pollutions endangering water quality downstream, implementation of flood control measures which may endanger downstream species dependent on floods, and similar, has been incorporated into the integrated water resources management.

Integrated approach implies unique management of surface and ground waters, as well as quantitative and qualitative water resources characteristics. Ground water resources cannot be observed separately from surface water resources, due to the cohesion of the hydrological cycle that links them. As contamination from the basin affects surface and ground waters concurrently, it is considered as another reason for a cohesive observation of all water resources within a river basin district.

Traditionally, water resources management is mostly orientated to the so-called „blue water “, i.e. water flowing through watercourses or found in ground aquifers. Based on the concept of integrated water resources management, management encompasses all water resources within a river basin, including also part of water used by vegetation and water “lost” through evapotranspiration. It is the so-called „green water“. Management of soil water and moisture increases efficiency of the exploitation of water resources within a river basin, as well as protection of vital ecosystems (GWP, 2004).

3.1.4 Integration of Human Factor Impacts

In the analysis of human activities, practically all aspects of integration involve knowledge and understanding of a natural system, its capacity, vulnerability and limitation (GWP, 2004). Such integration is a very complex task as it is necessary for all state policies and plans (spatial, economic and social) to consider impacts on water resources. Integration measures are thus required at all levels, from population to private sector which, upon making decisions on water exploitation, must consider a real value of water resources.

Integrated water resources management implies intersectoral integration of water resources within a national development policy. It means that water resources management policy should be integrated with national economic policy, as well as with national sector policies, especially in sectors of substantial influence on water resources such as energy sector, agriculture, etc. Water resources management system should develop mechanisms for intersectoral exchange of information and coordination procedure, as well as projects evaluation method from the aspect of their impact on water resources.

Inclusion of all stakeholders into water resources planning and management process is considered as one of key elements in the achievement of balanced and sustainable water resources management. In numerous cases, stakeholders have conflicting interests; therefore, it is necessary to develop, within integrated water resources management programme, operational mechanisms for settlement of conflicts. It is very important to identify individual water resources management functions towards the lowest suitable implementation level, and mobilise relevant stakeholders for each defined level of implementation.

In achievement of integrated water resources management, it is necessary to know significant criteria that take into account the social, economic, and natural conditions:

- Economic efficiency of water exploitation. Water shall be exploited with maximum efficiency, due to increasing shortage of water and financial resources, vulnerability of water resources and increasing water demands.
- Equity in water disposal. Approach to sufficient good quality water is a basic human right which must be universally recognised.
- Environmental sustainability. Present exploitation of water resources must be carried out without endangering their use by future generations.

3.1.5 Term „Sustainability“ in Water Resources Management

Nowadays, we more and more encounter the question whether our activities are sustainable or not. In literature, different forms of the term sustainability, primarily sustainable development, may be found. The most frequently used definition of the sustainable development is the definition of the World Commission on Environment and Development from 1986, which defines it as: “the development which satisfies present needs, and does not endanger the possibility for further generations to satisfy their needs“ (Grigg, 1996).

Concerning natural, or water resources, essence of the sustainable development is exploitation of natural resources in such a way that enables their equal or better exploitation for future generations. Accordingly, sustainable use of water resources requires respect of the hydrological cycle to prevent decrease of the capacity of renewable water resources after a long-term exploitation. In other words, water system sustainability requires harmonisation of water demands, i.e. harmonisation of water consumption with its availability in nature.

If, in the context of sustainable development, we pose a question on the quantity of fresh water available to humans, it does not take into account to total quantity of fresh water on the Earth but the velocity of renewal of fresh water stocks in global water circulation, or hydrological cycle. Therefore, the criterion for sustainable use of water resources refers to the so-called renewable fresh water resources, which occur on the Earth in form of precipitation. Namely, if the quantity of water abstracted from ground water sources and lakes exceeds the quantity of water supplemented by precipitation, such sources, from a long-term aspect, will dry up. One example of it is Aral Lake whose volume in the period from 1950-1990 reduced by over two thirds, as excessive quantities of water were taken from the inflow (River Amu-Darya and Syr-Darya) for needs of the irrigation system in agriculture (EC, 2006). Such unsustainable use of water resources led to an ecological catastrophe of the overall region (Novotny, 2003).

Possibility of converting salt sea water to fresh water initiated many hopes that world seas and oceans can be used as inexhaustible sources of fresh water. However, this technique is and remains expensive, contaminates environment and requires high energy consumption which also becomes increasingly expensive.

Reuse of water is one of key elements for the increase of water availability, or preservation of sustainable use of water resources. Formerly treated waste water may be indirectly reused in a way that, following the discharge into the watercourse and partial self-treatment, it is again used downstream. Indirect use of waste water means use of such water for industrial, agricultural, recreational and similar supply, after being treated in waste water treatment plants. Furthermore, such water can also be used for the recharge of ground water bodies.

Repeated, indirect use of treated water in the European Union countries has not yet reached an extraordinary expansion. However, the European Union Water Framework Directive (WFD; EC, 2000) introduces new dimension of water reuse, and it is to be expected that use of such water will be in increase in the following years.

3.1.6 Advantages and Benefits of Integrated Water Resources Management

Efficient integrated water resources management carries numerous advantages for all water resource users, as well as for environment, at local, regional and global level. Some of the advantages include the following (GWP, 2004):

- ***Troubleshooting.*** Numerous countries face water-related problems, difficult to be resolved by means of conventional single-sector approaches. Such problems include, for instance, droughts, floods, excessive intake of ground water reserves, diseases transmitted by water, soil and water, destruction of ecosystems, as well as escalating water conflicts. Settlement of the problems above may stem from regular authorities of the responsible agencies, and in such cases, cooperation of a larger number of different sectors is required. In problems above, integrated water resources management approach enables easier identification and implementation of adequate solution. Furthermore, it avoids very frequent situations of one problem solution causing a number of other problems (GWP, 2004a).

- ***Avoiding poor investments and expensive mistakes.*** Decisions on investments must be based on the evaluation of costs and benefits, having in mind their multiplicity and long-term dimension. In deciding on investments, it is necessary to consider economic infrastructure maintenance consequences, cost recovery possibilities, as well as short-term and long-term environmental impacts. In case of narrow sectoral thinking, environment is often neglected, leading to negative consequences for both social and economic development of the area. Integrated water resources management promotes consideration of environmental impacts. It provides avoidance of losses related to unsustainable development and high costs of repairing subsequent damages.
- ***Achieving maximum values for funds invested to infrastructure.*** Infrastructure planning, designing, and finally management by means of an integrated approach provide maximum return of investments, both in economic and social sense. Integration of water resources into wide development plans enables synergistic effect of investments, resulting in higher return than in case of single-sectoral approach.
- ***Strategic allocation of water resources.*** Following the review of water management approach, it has been found that in many countries allocation of water resources is not strategic, in sense of national development objectives (GWP, 2004a). Strategic allocation, implying subordination of sector or stakeholder objectives to general objectives of the society, is very rarely achieved in a direct way, through administrative decisions. It is more often achieved indirectly, by means of instruments such as water tariffs, so as introduction of appropriate or elimination of adverse and poorly advised incentives and subventions.

Integrated water resources management primarily benefits to the poorest population which is most exposed to the problem of water scarcity. Use of this way of water resources management increases security and reduces water supply costs for households primarily, reduces waste water treatment costs, as the pollution problem is resolved through this approach with considerably higher efficiency.

The focus to integrated water resources management and efficient use of water resources leads to everyday increase of recycled water quantities. Fees for discharge of contaminated water, imposed through legal regulations, resulted in higher efficiency in use of water resources in industrialised countries, and thus in the achievement of substantial financial savings for owners of industrial and other companies.

Likewise, as the poorest are given the possibility to take full participation in decision making and secure themselves and their families safety in water supply through the processes of integrated water resources management, the environment has perhaps for the first time been allocated an appropriate position through this process. Namely, in former deciding on the so-called "water distribution", needs of the environment, or water-dependant ecosystems, have mostly been neglected at the cost of other user categories, especially industry.

3.2 Principles of Integrated Water Resources Management

Main target of water resources management is the achievement of a complete and adjusted water regime on certain territory (Novotny, 2003). It implies concern for spatial distribution and status of water quantity and quality in a way that best suits the particular area and period of time. Considering the stated, integrated water resources management attempts to secure sufficient quantity of good quality drinking water for public population supply, required quantity of water for different economic needs, protect human lives and material goods against adverse water effects and achieve and preserve good status of waters due to the preservation of water and other water-dependant ecosystems. In order to succeed in such attempts, it is necessary to adjust water management measures with environment management measures, and to ensure good status of surface and ground waters.

It is more than obvious that, on one side, demands both for drinking and technological water are in constant increase, while, on the other side, there is a continuing tendency of decrease of both surface and ground water quality. It becomes clear that due to restrictions in resources, it is necessary to provide continuous assessment of the quantity and quality of water in nature, and to preserve it by means of optimum management. Optimum means satisfying social, economic and environmental objectives. Precondition for achievement of these targets is that water becomes a concern and task of each individual, which cannot be achieved unless people become aware of their participation in the hydrological cycle.

Such situation indicates the fact that water management shall be based on the principles with much higher seriousness and power than legal principles, although many of these principles have become a part of legal regulations, both worldwide and in Bosnia and Herzegovina.

There are numerous principles relevant to integrated water resources management, all of them suitable for application in certain field. However, among all such principles, special position is given to the so-called „Dublin principles“. These are four principles, carefully formulated in 1992 at the International Conference on Waters and Environment, held in Dublin. Dublin principles, as well as other generally accepted principles, are aimed at improvement of scarce water resources management. Dublin principles were universally supported within the international community, and represent main principles for integrated water resources management.

Four Dublin principles are (ACC/ISGWR, 1992):

- Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
- Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.
- Women play a central part in the provision, management and safeguarding of water.
- Water has an economic value in all its competing uses and should be recognized as an economic good.

These principles are not static and are constantly subject to improvement and upgrading, by means of experience and practical work.

Among other generally accepted principles of water resources management, in a way contained within four Dublin principles, following shall be extracted:

- Water is an irreplaceable condition of life and work. Obligation of all is to carefully protect its quality, as use it economically and rationally.
- Waters are managed based on the principle of water system unity and principle of sustainable development which satisfies needs of present generation and does not endanger the right or the possibility of future generations to accomplish it for themselves.
- Water does not recognise borders – territorial units for water management are river basin districts as hydrographical and economic wholes. Administrative-territorial unit borders shall not be an obstruction to integrated water resources management within such territories.
- In preparation and adoption of plans as a basis in water resources management, starting point refers to the responsibility to provide integral environ-

ment protection and accomplish general and economic development of the country.

- Fees charged for the use of water exceeding limits of allowed general use, as well as for each degradation of water quality, are proportional to the use, or level and scope of impacts on water status changes.

Water as restricted and vulnerable resource. The concept of water as a restricted resource stems from the fact that within the hydrological cycle water occurs on certain territory and in observed period of time in certain, maximum quantities, which cannot be considerably altered by human acts. Although solutions for certain increase of the available quantities of drinking water have occurred recently (reduction of natural evaporation or desalinisation of sea water, which has become a feasible technical solution), due to high costs and complex implementation, such solutions are rather restricted in scope and application.

Different human activities may have major impact on available quantities and quality of water resources. Some of the activities result in negative effects, for example excessive exploitation of ground water, discharge of untreated waste waters, spatial interventions (forest cutting, urbanisation), and similar. Positive effects mostly relate to regulation of inconvenient spatial and time distribution of water resources in nature (prevention of floods, construction of accumulations for increase of minimum water quantities during dry periods, etc.).

Regardless of the self-treatment (auto purification) of waters that occurs in nature, whereby different physical, chemical and biochemical processes cause natural reduction of contents and concentrations of contaminating substances in natural waters, infinite quantity of pollution cannot be discharged into water due to limited capacity of such processes. Therefore, water is considered a vulnerable resource which must be maintained to provide long-term functions demanded by its users.

Principle of participation of stakeholders. Issues related to water are a subject of interests of all society members, thus, it can be stated that in this case all groups represent stakeholders. However, actual participation occurs only when stakeholders are a part of the decision making process (Cap-Net and GWP, 2005). Participation in the decision making process can be: (i) direct, when stakeholders directly affect decisions in terms of water resources and (ii) indirect, when decision making is pursued through democratically selected representatives.

Participation in the decision making process does not mean only consultations on water management issues, but also the possibility of affecting decisions at different management levels. Namely, different consultation mechanisms, among others, surveys and meetings with stakeholders, do not provide actual participation, especially if organised primarily for legitimisation of already adopted decisions, weakening the political opposition or delay of implementation measures which may have a substantial impact on powerful interest groups (GWP, 2004).

Due to different and often conflicting stakeholder interests, the principle of participation of stakeholders implies accomplishment of consensus on water management issues, to achieve stable and sustainable management process on the long run. Necessary assumption for the consensus is high awareness of stakeholders on needs for a compromise in certain issues, to achieve common good for all. As it is not always possible to accomplish consensus, adequate mechanisms for settlement of conflicts must be predicted in the decision making process.

Participation in the decision making process shall be provided at the lowest possible level, to enable true participation of stakeholders and efficient decision making. The lowest level for making certain decisions may perhaps be a household or a farm. On the other side, management of transboundary river basins will require decision making at the level of intergovernmental commissions or other similar international coordination bodies responsible for decision making.

Gender dimension. Woman has an important role in managing water within a household, or a family. However, her role in water management in the society was not adequately treated in the past (Cap-Net and GWP, 2005). There is a very small number of women in water management decision making bodies, especially in the developing countries.

Since 1980, much has been done in promoting the importance of the role of women in water management. Thus, during the International Decade for Water Supply and Sanitation (1981-1990), it was shown that higher inclusion of women into water supply and sanitation projects leads to better project results, lower waste of water, and cleaner environment around water sources. However, main role of women as water suppliers and consumers, as well as human environment protectors, was rarely adequately reflected in the process of planning, development and management of water resources, as well as related decision making.

Implementation of water programmes and provision of the inclusion of women into water-related development issues was brought into focus on the 58th conference of the General Assembly of the United Nations, held in December 2003, when the period from 2005-2015 was proclaimed the International Decade of Action „Water for Life“ (GWA, 2006).

For the development of efficient participation of women in decision making at all levels, it is necessary to consider the fact that, in different societies, men and women are assigned specific social, economic and cultural roles. Therefore, it is necessary to, upon decision making in water sector, consider gender dimension and define mechanisms for inclusion of women into the process of integrated water resources management.

Water as economic good. Numerous failures in water management in the past were a consequence of the fact that water was often considered a free good, or a good whose value was not fully understood. In order to achieve highest benefits of this restricted good, it is necessary to change the perception on water value. Management of water as economic good enables accomplishment of social goals, such as efficient and fair distribution of water, and encourages saving and protection of this resource (Cap-Net and GWP, 2005).

This concept of water as a good with certain value is very often interpreted as such that water must have a cost-covering tariff that everyone has to pay, which is an obvious misunderstanding (Savenije and Hoekstra, 2003). Namely, the concept of water as economic good means that the decisions on allocation and use of this resource must be made on the basis of economic reasons. To avoid misunderstandings, it is thereby necessary to distinct concepts of water value and water price (GWP, 2004). The value of water is defined by means of the concept of opportunity cost, which represents the lost resource value as a consequence of the decision to use resources for the observed, and not for another purpose (McGuigan et al., 1999). Water tariff is an economic instrument for influencing behaviour in terms of saving and efficient use of water, ensuring stimulation in terms of water demand management, providing costs recovery, while the tariff also reflects the readiness of consumers to pay additional investments in services related to water resources (GWP, 2004).

Management of water as economic good represents a significant mechanism for making decisions on allocation of water resources among different sectors that use water, as well as among different users within a single sector (Cap-Net and GWP, 2005). This is especially important in situations when there are no more technical and financial possibilities for provision of new water quantities, but existing limited quantities must be distributed to interested users.

3.3 Implementation of Integrated Water Resources Management

Implementation of water resources management is a continuous periodic process schematically presented in Figure 3.3. Namely, integrated water resources management shall be observed as a continuous process, conducted iteratively or periodically, and not as an activity which occurs once and is linear by its nature. This approach is based on effective water resources management encouraging a process of good and continuous management, which is an answer to changes in established targets and demands (GWP, 2004a).

3.3.1 Main Steps in IWRM Implementation

As a process that investigates possibilities of accomplishing improvements in existing unsustainable water resources management systems, IWRM does not have precisely defined beginning and end. In initiating the planning process, IWRM may be of internal or external character, and may occur as a combination of the two impacts. Regardless of the reason and source of process initiative, considerably important stating point is the awareness of IWRM concept, which leads to achieving sustainable development of water resources management. Without such awareness, it is not possible to accomplish complete consensus and political will for implementation of the IWRM process by applicable authorities, in which case the process itself becomes questionable.

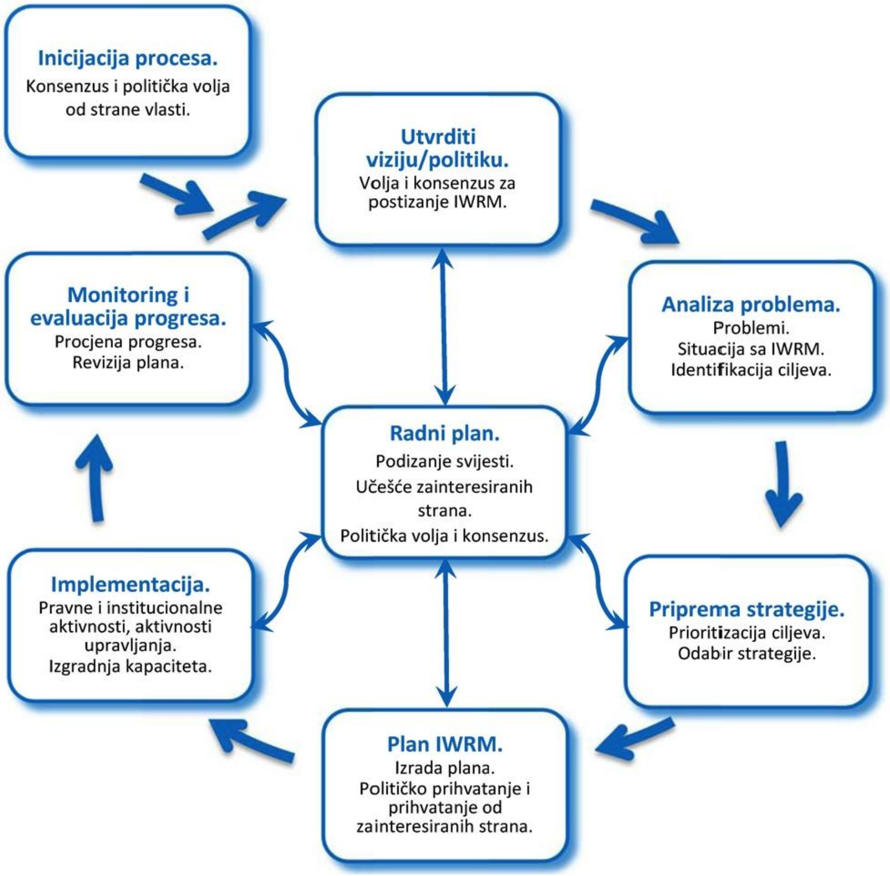

Figure 3.3 Main Steps in IWRM Implementation (Source: Cap-Net and GWP, 2005)

Formulation of a national vision and policy is crucial for definition of principles and guidelines of future actions in water sector, as well as guidelines for IWRM planning process. Vision and policy in water sector shall be formulated in a way to provide achievement of sustainable water management within the IWRM process. In this phase, the will and consensus of key stakeholders for achievement of integrated water resources management are re-examined.

In order to define appropriate actions for achievement of the formulated vision, it is very important to consider the existing situation in all fields significant for water management. For the analyses of existing problems, it is necessary to carry out consultations with all stakeholders, including different government institutions, to provide good understanding of targets and demand of the respective parties in terms of existing water resources management. During this phase, all advantages and disadvantages of the existing water management system are being analysed, as a basis for definition of water management targets, to be transformed into concrete activities within the frame of the IWRM plan in the following implementation phases.

Based on the water sector problem analysis, strategy for implementation of the integrated water resources management is defined (Figure 3.3). First step in preparation of the strategy is the establishment of targets for the water resources management plan. The targets should be formulated realistically, based on the consideration of the existing situation of water resources, and taking into account formulated vision and policy in water sector. For each established target, it is necessary to consider possible strategy of its accomplishment and solutions to overcome problems identified in the previous phase. Although certain solutions may be noticed already in the analysing phase, all problem solutions must be identified within the strategy development phase, and analysed from the aspect of feasibility, including advantages and disadvantages in terms of achieving the targets. Selected strategy and solutions shall be the most justifying from the aspect of sustainable water resources management, formulated water sector vision and IWRM targets.

Integrated water resources management plan can be prepared on the basis of the formulated vision, identified problems and identified strategy. Depending on the context of the IWRM implementation process, there may be a need to prepare and upgrade the draft plan several times, not only to identify realistic and sustainable activities and the budget for their implementation, but for different stakeholders to agree with all proposed plan components. Official approval of the plan by authorised institutions is a required precondition for the beginning of its implementation (Cap-Net and GWP, 2005).

Preparation of the IWRM plan is a very important step for accomplishment of integrated water resources management, but it is not the end of the process. Namely, the plan shall be implemented to achieve established targets and identified target vision. Implementation implies execution of different legal and institutional activities, as well as water resources management activities defined in the IWRM plan. Development of capacities of all participants of the plan implementation is an important precondition for the efficient implementation.

Implementation of the plan is very frequently a phase within which crucial problems in the IWRM process occur, questioning accomplishment of sustainable water use. The most frequent causes of no or partial implementation of IWRM plans include (Cap-Net and GWP, 2005):

- lack of political will and consensus for achievement of integrated water resources management;
- non-realistic plan, requiring use of resources unavailable to authorised authorities;
- in essence, the plan has not been accepted by all stakeholders, especially the powerful ones.

Therefore, monitoring of the plan implementation is a necessary step in determining whether water resources management is being implemented in accordance with the plan and whether certain possible correction in the implementation activities are required, or whether the plan itself shall be corrected or not. In the latter case, there is actually a need to reopen the cycle of IWRM implementation, in which, if needed, results of all process phases from the previous cycle are redefined. In order to achieve sustainable use of water resources, which is a long-term task and process, repetition of IWRM implementation activities (Figure 3.3) shall be carried out in periodical intervals (Cap-Net and GWP, 2005).

In all afore-mentioned phases of the IWRM programme implementation, it is necessary to ensure and inspect political will and consensus of all stakeholders for the process implementation (Figure 3.3). Whether the described process will lead towards sustainable use of water resources or not depends on the participation of all stakeholders and raise of their awareness as key factors.

3.3.2 Planning and Water Management Plans

Planning is a key mechanism for achievement of integrated water resources management. Water resources management planning is planning of the development, protection and use of water as a scarce resource, used for adjustment of available water resources with demands, taking into account established national targets and restrictions, as well as stakeholder interests (Savenije and Hoekstra, 2003). Upon planning, it is necessary to apply a strategic approach, enabling achievement of such solutions to answer perceived problems related to water resources.

3.3.2.1 Generally about Integrated Water Resources Management Planning

In the process of IWRM planning, it is necessary to identify and consider larger number of strategies and measures for accomplishment of the identified vision and strategic goals. Analysis of alternative strategies is a complex task; therefore, different methods are often used for decision making simplification purposes. Most of such methods are focused to the interaction of interests of different stakeholders, to facilitate the attempt of the decision makers to understand their role in the process.

This approach is different from approaches often used in the past, and based on different optimisation techniques (e.g. linear programming). Nowadays, widely spread is the opinion that optimisation techniques have restricted application, mostly due to two key reasons contributing to the complexity of IWRM planning process (Savenije and Hoekstra, 2003):

- Uncertainty in terms of future events (hydrologic and climate scenarios, technological and economic development scenarios, political scenarios). There are relatively reliable tools today for settlement of problems related to uncertainty in terms of natural and physical processes, but not with assumptions referring to social and economic processes. Therefore, for example, price of oil and agricultural products, interest rates, ratio of currencies on exchange rate lists and similar are values difficult to predict, and analysis of the water sector policy considerably depends on them. In addition, it is not only difficult to understand functioning of social mechanisms at certain moment in time, but such mechanisms also change throughout time.
- Apart from all afore-mentioned uncertainties, there is always a conflict of different interests. In case of integrated water resources management, decisions are rarely made on the basis of an “optimal” scenario, but the option acceptable to relevant stakeholders and representing an acceptable compromise solution is adopted.

Taking into account afore-mentioned and other reasons affecting the complexity of the planning process, it has become obvious that IWRM planning does not imply simple calculation of the best i.e. optimal solution. As the planning process requires multidiscipline and constant participation of all stakeholders, it is necessary to apply the flexible approach to guarantee the acceptability of the proposed water management strategy to all.

Expected results of the water resources management planning is the preparation of feasible and acceptable IWRM plan, which is a document containing answers to the following questions: (i) what shall be done to achieve sustainable water management, (ii) who shall implement individual activities, (iii) when shall individual activities be implemented (iv) which resources are available for the plan implementation.

Integrated water resources management plan can cover a wide scope of questions, which largely depend on the context of the situation in the country and in the referred river basin. Therefore, the content of each management plan is different. However, integrated water resources management plans should cover at least the below listed issues (Cap-Net and GWP, 2005):

- Description of the existing water resources management system to be replaced with the plan under construction, including elaboration of the following issues: (i) historical background of the existing management system, (ii) existing legal and institutional framework, (iii) restrictions of the existing management system.
- Description of the existing status of water resources on the plan-related area, including analysis of the following problems: (i) spatial and time distribution of water resources, (ii) analysis of water users and the way of use of water resources, (iii) social and institutional water management framework, (iv) spatial and time distribution of floods and drought occurrence, (v) existing strategies for water conservation and management of water demands, (vi) other issues initiated by stakeholders during consultations.
- Description of water resources management objectives.
- Plan implementation strategy, including: (i) identification and description of activities for the plan implementation, (ii) overview of expected results, (iii) cost analysis for implementation of activities and (iv) time schedule with individual activities. Upon elaboration of the plan, numerous activities are usually presented per individual fields, for example: Research and Development, Water Information System, Human Resources, etc.
- Integrated water resources management plan should include a chapter in which the plan is linked to other national sectoral plans (for example, how does the IWRM plan relate to the Strategy to End Poverty, etc.).

Throughout preparation of the plan, it is necessary to conduct continuous consultations with stakeholders, especially the parties which are of key importance for successful implementation. Consultations may result in the need to prepare the plan several times, thus the preparation of the draft plan may be understood as an iterative process which ends only upon acceptance of the draft plan by key stakeholders.

For the purpose of adequate orientation of consultations and final acceptance of the plan, it is necessary, prior to start of the plan preparation, to achieve consensus of all stakeholders on conditions which must be met for acceptance and adoption of the plan. If the conditions have been identified at the beginning and if the participation of stakeholders in preparation of the draft plan was satisfactory, official acceptance and adoption of the plan shall not be a problem. Otherwise, adoption of the plan and its subsequent implementation may be hard or fully disabled.

3.3.2.2 Water Management Planning and EU Water Framework Directive

One of crucial water policy instruments nowadays is the Water Framework Directive – WFD (EC, 2000) defining principles of water resources management in the European Union (EU). Based on the Water Framework Directive, EU member countries must develop River Basin Management Plans (RBMP) for each River Basin District (RBD). These plans are key documents in water management planning stipulating specific objectives and measures for their achievement. In accordance with the WFD, member countries had to prepare water resources management plans by 2009, and revise and renew them each 6 years thereafter.

Based on Annex VII of the Water Framework Directive, it is anticipated for the management plans to essentially include and elaborate below listed elements:

- description of water district characteristics;
- major pressures and impact of human activities to the status of surface and ground waters;
- identification and mapping of the protected areas;
- results of the water monitoring programme;
- description of water management targets;
- results of the economic analysis in terms of water exploitation;
- action programme for achievement of targets;
- overview of other management programmes and plans for the observed water district;
- overview of implemented public consultations measures and their results;
- overview of authorized institutions;
- contact persons and procedures used for collection of documentation required for preparation of the management plan.

Water Framework Directive has set new targets for water resources requiring from the member countries to achieve the so-called “good status” of water bodies by 2015 and to prevent deterioration of the status of waters. Good status means that water quality indicates only to minor changes caused by human activities compared to undisturbed conditions within a water body. WFD allows deviation from this standard in case the achievement of the so-called “alternative targets” is concerned. This possibility represents a mechanism for consideration of other environmental, social and economic priorities, in addition to the priorities referring to water resources management. Alternative water management targets are applicable only in exceptional cases (Defra, 2006).

Action programme should define all measures – activities and mechanisms (legal, economic and other instruments), for achievement of WFD targets and the River

Basin Management Plan. Some of the proposed measures are applied on the referred water district, while some measures are applicable on a wider or narrower geographic area (national, regional, local level). In principle, different types of measures are applicable to different geographic scope.

Water Framework Directive predicts consultations with stakeholders concerning the draft of the plan in duration of minimum 6 months. During this process, not only collection of views on the draft plan is carried out, but also engagement of stakeholders in the settlement of conflicting interests and problems.

Planning process, in compliance with the WFD, involves revision of numerous existing plans and programmes, in order to harmonise them, where necessary, with the River Basin Management Plan and WFD targets (Defra, 2006). This process of harmonisation is bilateral process; public institutions outside water sector should have the capacity of affecting the process for preparation of river basin management plans, and also institutions within water sector should have the capacity to affect other sectoral strategies and plans.

3.3.3 Implementation of Integrated Water Resources Management

Integrated water resources management process has been or is being established in many countries worldwide. On the 4th World Water Forum, held in 2006 in Mexico, it was announced that 74% of the analysed 95 countries have already adopted IWRM strategy or have been in the process of determining the strategy (Hassing et al., 2009). This and some other analyses (for instance UN-Water, 2008) have indicated that the countries in the world increasingly build their capacities in terms of the integrated water resources management process.

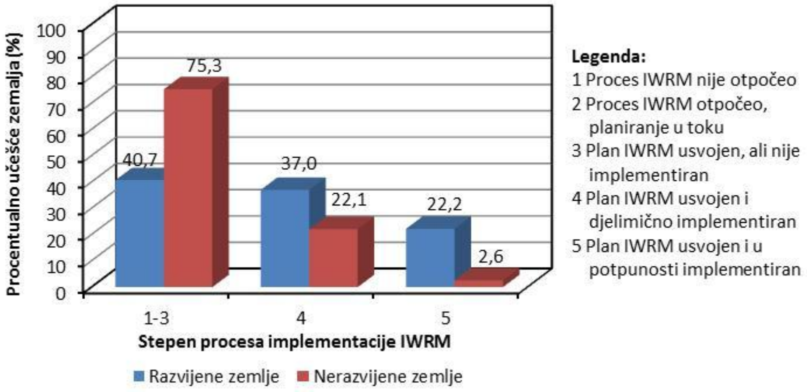

Figure 3.4 Level of IWRM Process Implementation Worldwide

Within remaining 41% of the developed countries (i) IWRM has not commenced yet, or (ii) has commenced, but with the planning in progress, or (iii) IWRM plan has been adopted but not yet implemented. Over 75% of the undeveloped countries have not yet entered the process of IWRM implementation, or have not even started the IWRM process, while only around 2,6% of the countries had implemented the IWRM plan (Figure 3.4).

Integrated water resources management process has faced numerous challenges throughout its application. One of such challenges is the integration of water policy into other sectors within a state (Hassing et al., 2009). Problems like financial issues, restrictions in resources and human capacities, institutional barriers and other factors represent restrictions that define the integration implementation boundaries. There are certain other issues as well that are challenging to practical implementation of the IWRM process, such as cooperation within transboundary river basin districts, methodology for monitoring progress of IWRM implementation, establishment of adequate institutional framework for the implementation, and similar.

As in other reforming processes, IWRM is also a process requiring certain period of time, possible several decades, for establishment of the water management system in compliance with general principles of this process. In the European Union developed countries (for example France and Spain), establishment of current water management system compliant with the principles of integrate water resources management and Water Framework Directive required over 50 years (Hassing et al., 2009). In undeveloped and developing countries, with lower institutional reforming capacity, this process is considerably slower, as a consequence of numerous factors decelerating reforms and establishment of the IWRM system.

4

Sustainable Water Consumption

Increase in the number of people on the Earth, as well as increase in water demands, occurring as a consequence of higher living standard, change in living habits and higher industrial and agricultural production, result in the increase in water consumption. Consumed water, depending on the way of use, becomes polluted with hazardous substances and, regardless of all available treatment technologies, pure water stocks are decreasing.

Analyses indicate that the quantity of global water intake was 3,790 km^3 (whereof the quantity of consumed water is 2,070 km^3 or 61%) in 1995, and 4,430 km^3 (whereof the quantity of consumed water is 2,304 km^3 or 52%) in 2000 (Shiklomanov, 1999). During 2000, 57% of taken water and 70% of consumed water belongs to the Asian Continent, with the largest irrigated surfaces (UNESCO, 1999). Expected future increase of water intake is 10-12% every 10 years, thus, it is anticipated that the quantity of water taken by 2025 will be 5,240 km^3, which is 1.38 times more than in 1995. Furthermore, expectations include also gradual increase in water consumption of up to 1.33 times (UNESCO, 1999).

In the following decades, it is anticipated that Africa and South America will reach the highest water intake (anticipated increase is 1.5-1.6 times), while in Europe and North America, this increase in water intake will be slightly lower (1.2 times) (Harrison and Pearce, 2004; Shiklomanov, 1999; UNESCO, 1999). Global water footprint is 1,240 m^3/inh/year. In the absolute amount, India has the highest water footprint in the world (987 Gm^3/year). However, the number of Indian population in relation to the total number is 17%, while their water footprint contribution is 13%. Considering relative relations, USA population has the highest water footprint of 2,480 m^3/inh/year, followed by Greece, Italy and Spain with 2,300-2,400 m^3/ inh/year. On the other side, China has relatively low water footprint which of approximately 700 m^3/ inh/year. (Hoekstra and Chapagain, 2007).

During the 20th century, the quantity of water taken worldwide (by means of pumping or other means) increased for more than six times, which is twice as fast as the increase of world population during the same period. Water intake will continue to grow, not only due to the population growth, but also due to constantly growing socio-economic needs. Excessive use is not sustainable. It has a very negative impact on the quality and quantity of the remaining water, as well as ecosystems depending on it. It is obvious that we have to decrease our demands, reduce the quantity of pumped water to the lowest possible level, and increase efficiency in water use. As early as 1996, Gleick (Gleick, 1996) defined sustainable use of water as „the use of water that supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrological cycle or the ecological systems that depend on it“.

4.1 Water Consumption Indicators

4.1.1 Water Efficiency

Water efficiency is the indicator of the relation between the quantity of water required for certain purpose and the quantity of water delivered to the consumer (Vicekers, 2003). Water saving is a similar concept, with the accent on implementation of certain activity with minimum quantity of water. Efficiency is more focused to reduction of waste water, than to the restriction of its use. In case of efficiency, accent is on measuring water consumption throughout the process, change of the way of water use for certain purposes, equipment maintenance, improvement of processes and products aimed at water recirculation and recycling, and similar. Application of water recirculation and recycling in industrial plants can reduce water consumption by 50% and more, achieving also additional benefit with regard to waste water reduction.

4.1.2 Water Productivity

Water productivity is the indicator that shows the quantity of water used for formation of the product unit, and is most frequently applied in agriculture to describe the quantity of water used for cattle breeding, or cultivation of corn and other agricultural cultures. The indicator is used in industry as well, and expressed with regard to the product unit. Such water consumption expression enables comparison at sector levels.

4.1.3 Water Footprint

Water footprint is the indicator of water consumption that takes into consideration the living cycle of a product or an activity formation, including both direct and indirect consumption of water by consumers and manufacturers. Water footprint of a person, community or a business entity is defined as the total quantity of fresh water used for production of goods and services, and consumed by a person, community or a production plant. In case of a production plant, water footprint is an indicator useful for the analysis of water consumption, not only direct consumption within the production process, but also within the total chain of supply, from resource to distribution and use of product. The founder of this concept, which also considers consumption as the factor of impacts on water resources, is the professor Arjen Y. Hoekstra.

4.2 Water Consumption

4.2.1 Consumption of Water in Agriculture

Major part of water, 70% of water available worldwide, is consumed in agriculture (Appelgren, 2004; Pimentel and Pimentel, 2008). Approximately 250 million of hectares of arable land is irrigated. It represents only 17% of the total arable land, but more than one third of the total world's harvest is gained from it. Consumption is particularly high in dry areas, such as the Middle East, Northern Africa, and south-western part of USA, where artificial irrigation is required almost throughout the entire year. Furthermore, states like Pakistan, India, Indonesia, and China depend on irrigation, used to accomplish more than a half of the total production of provisions. In order to feed the increasing number of population, it is necessary to cultivate and irrigate more and more land. Furthermore, consumption of water for cattle breeding purposes has incresaed in the last years. In many developing countries, 90% of the water intake is used for irrigation (Figure 4.1). In England, a country abundant in precipitation, only 1% of the water intake is used for irrigation, while in Spain, Portugal and Greece it exceeds 70%.

Irrigation is essential for life, especially in the developing countries that are trying to secure sufficient food for their population. Increasing number of population requires even more water for food production, but conflicts for water and inefficient irrigation will endanger its production in future. The map presented in figure 4.2 shows the area of insufficient water to satisfy irrigation needs (Millennium Ecosystem Assessment, 2005).

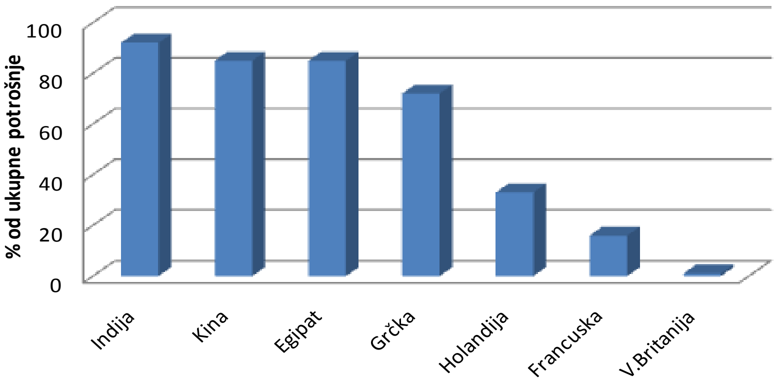

Figure 4.1 Percentage of Total Water Consumed in Agriculture (Source: Saejis ivan Berkel,1996)

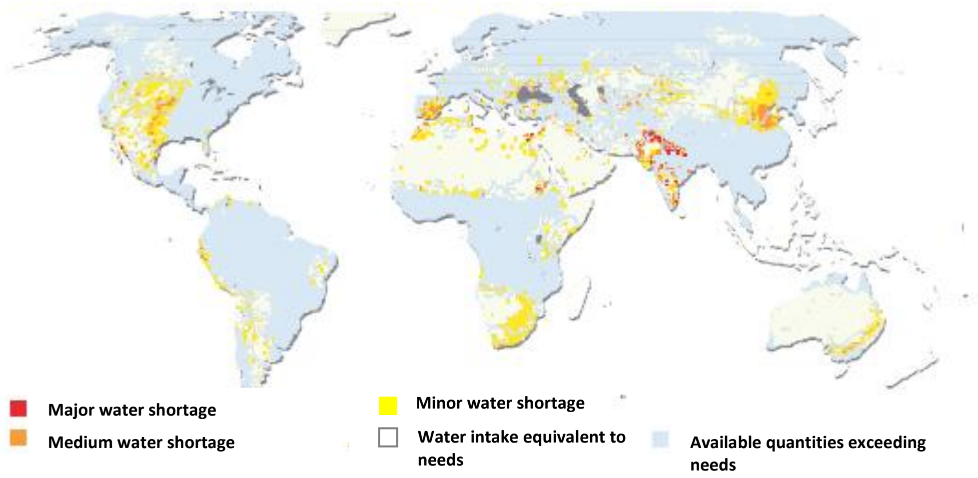

Figure 4.2 Insustainable Use of Water for Irrigation Purposes (Source: Millennium Ecosystem Assessment,2005a)

In many irrigation systems, over 60% of water is lost on its way from the source to the plant. Higher efficiency irrigation systems would contribute to major water preservation. Similar situation is in industry and households as well. The surface marked in grey in figure 4.3 represents the difference between water intake and water consumption.

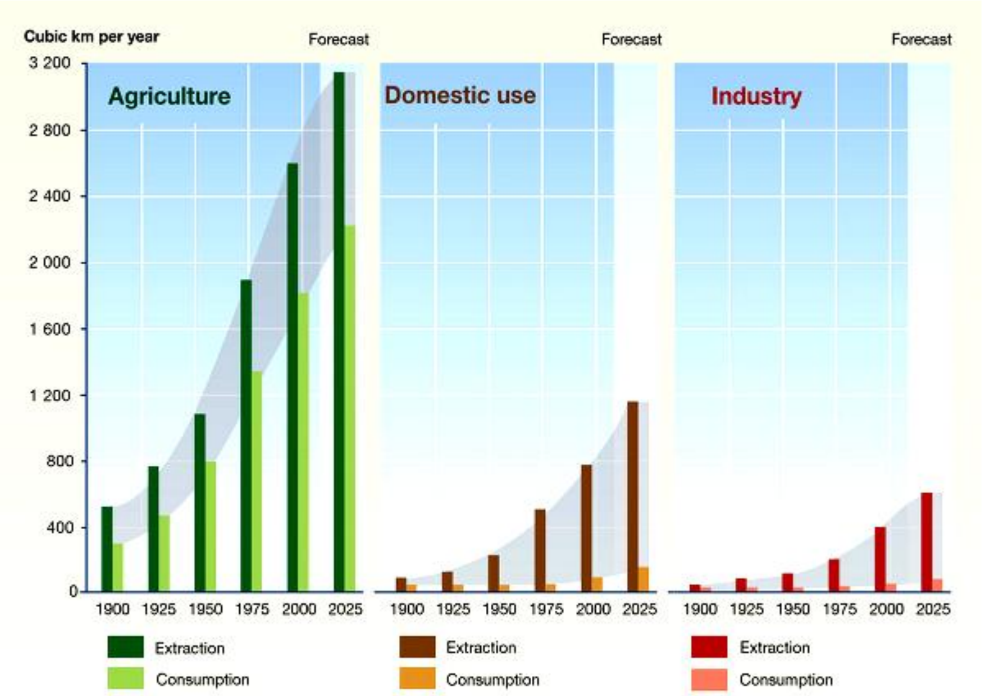

Figure 4.3 Ratio of Water Intake and Water Consumption in Agriculture, Industry and Households (Source: Shiklomanov,1999)

Consumption of water in agriculture can be analysed based on the water footprint. Thus, if the consumption of water from resource production to the final product is added to the calculation of the total quantity of water, it is necessary to provide:

- 500 l of water for production of 1 kg of potato;
- 3,000 l of water for production of 1 kg of rice;
- 900 l of water for production of 1 kg of maize;
- 6,100 l of water for production of 1 kg of mutton;
- 15,500 l of water for production of 1 kg of beef.

For industrial beef production, the period required prior to slaughtering is three years. Approximately 200 kg of boneless meat is produced from an average ox.

During that period, the animal eats around 1,300 kg of corn and around 7,200 kg of food supplements, and consumes 24 m^3 of drinking water and 7.0 m^3 of cultivation water. It means that 6.5 kg of corn, 36 kg of food supplements and 155 litres of water are consumed per one kilogram of meat. The quantity of water consumed for production of animal food, which is in average 15,300 litres, is added to the total quantity of water. For production of wheat, approximately 790 billion of m^3 of water is used per year, what makes 12% of the total consumption of water for corn production. The quantity of water used for the production of maize is approximately 550 billion of m^3 per year, what makes 8% of the global consumption for corn production purposes.

4.2.2 Consumption of Water in Industry

In industry, water is used for different purposes. In many industries, such as dairy production, production of alcoholic and non-alcoholic beverages, production of pharmaceutical products in liquid state, cosmetics industry, and similar, water is a constituent part of products. Water that is a constituent part of products or is used for growing plants as agricultural products is called “virtual water”. Water is used in auxiliary industrial processes as well, for industrial steam production, cooling, and maintenance and cleaning of industrial plants and facilities. In major technological process, water is used for washing of resources, preparation of solutions, semi-product and final product flushing in different phases of the production process. The largest individual water consumers in industry are energy production plants, such as thermal power plants and nuclear power plants, using water for cooling purposes. Hydro power plants are not far behind, whereby water intake depends on the allocation of artificial accumulations that may be used for irrigation, water supply, flood protection, recreation, etc.

Following agriculture, industry is the second largest water consumer. Out of the total water quantity, 22% of water worldwide belongs to industry. The quantity varies from country to country, depending on the structure of the industrial sector, as well as the level of application of best techniques for the achievement of resource efficiency and pollution prevention.

Based on the research conducted in beer production plants in BiH (Midžić Kurtagić and Silajdžić, 2008), water consumption per product unit varies from 0.9 to 1.45 m^3/hl (Figure 4.4).

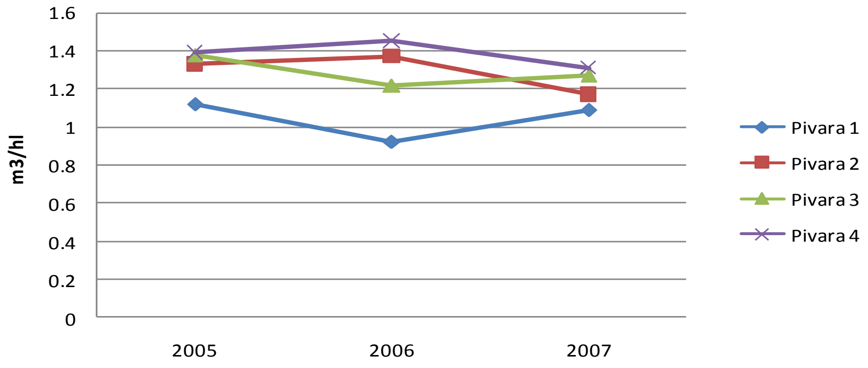

Figure 4.4 Water Consumption in Breweries in BiH, 2005-2007 (Source: Midžić Kurtagić and Silajdžić, 2008)

Consumption of water in modern breweries is within the range from 0.4 to 1.0 m^3/hl of the produced beer (Table 4.4). German beer industry reports on water consumption from 0.49 to 0.89 m^3/hl. A well managed brewery produces one hectolitre of beer using 0.5-0.6 m^3 of water (Midžić Kurtagić and Silajdžić, 2008), indicating to the conclusion that the consumption of water in beer production plants in BiH is unproductive.

Table 4.1 Water Consumption in BiH Breweries

Indicator	Value per Reference Document (EC, 2006a)	Value per Reference Document (UNEP, 1996)
Water Consumption (m^3/hl)	0.32-1.0	0.4-1.0

4.2.3 Water Consumption in Settlements

Water consumption depends on the availability and price of water, climate, standard and individual habits of consumers (drinking, bathing, washing, garden watering). Water consumption is higher in towns in the countries with higher national income. Consumption of water in households, and in facilities such as restaurants and hospitals, takes a smaller share in the world's water consumption, of 8% in average. In South California, living standard is high, and majority of population lives in houses with gardens and pools, thus the daily water consumption is 3,000 litres per person. Based on the data of the World Health Organisation (WHO), minimum daily demand for water per person is 50 litres.

Distribution of water consumption per individual uses is different, and water is most used for toilet, laundry and bathing (Figure 4.5).

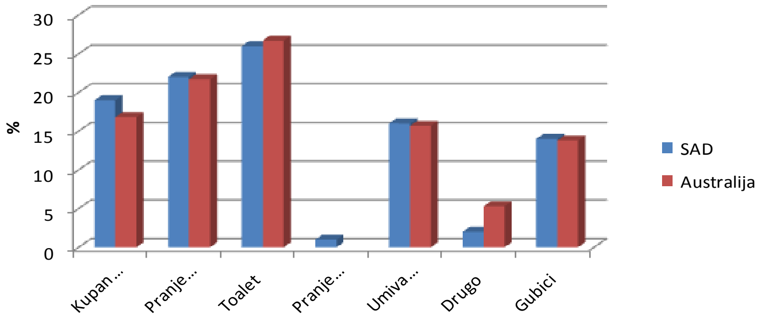

Figure 4.5 Distribution of Water Consumption in % for USA and Australia (Source: US EPA, NWC)

Water consumption is also an indicator of the status of water supply system as it includes water losses from the water intake to a consumer, as well as losses in consumers' systems. Losses at consumers in USA and Australia are approximately 14%. Water losses in water supply systems of East European countries are significant and amount to around 50%. Sweden, Finland, Denmark are countries with water losses below 20%, and Germany with the losses below 5% (EEA, 2003).

Research conducted in BiH (IHGF, 2010), involved 20 municipalities whereby high water losses were defined, as follows:

- In the Federation of BiH, losses in average amount to around 67,4%;
- In the Republic of Srpska, losses in average amount to around 52,2%.

Total balance of water intake, delivery and losses considering 20 researched municipalities results in 61% of non-revenue water or unaccounted for water (Table 4.2).

Table 4.2 Total Intake, Delivery and Losses in 20 Municipalities, BiH, 2010

Type	Quantity
Billed water (m^3)	20,979,002
Water intake (m^3)	56,093,589
Unbilled production (m^3)	34,200,043
LOSS IN WATER PRODUCTION (%)	61

These are typical indicators of unsustainable consumption.

4.3 Examples of Sustainable Water Consumption

4.3.1 Sustainable Consumption in Industry

Possibilities for prevention and minimisation of water consumption in industrial processes should be searched in (Figure 4.6):

- product modifications;
- replacement of the resource and/or supplementary materials;
- technological changes;
- equipment modification;
- better process control;
- good management, or introduction of administrative, institutional and procedure measures;
- reuse of water in production process;
- production of useful by-products.

Figure 4.6 Prevention and Minimisation Possibilities (Source: UNEP/DEPA, 2000)

Intervention in the production process at the point of consumption and creation of a waste flow, can lead to its reduction or full elimination, improve overall resource efficienct, and concurrently reduce production costs. Possible prevention measures for water consumption are presented in table 4.3.

An example of application of measures for reduction of water consumption and emissions for the industrial wire production plant in BiH is given below. The plant was designed for the production capacity of 188,000 tons of low-carbon wire per year, 40,000 tons of high-carbon wire per year, and 3,300 tons of iron ropes per 7,400 of working hours. Actual production capacity is considerably lower than the designed capacity and, in the time of research, it amounted to the total of 8,376 t per year (Midžić Kurtagić, 2011).

Table 4.3 Possible Prevention Measures to Reduce Water Consumption

Possible Changes	Prevention and Impact Minimisation Measures
Resources/Supplementary Materials	Avoid or reduce use of hazardous and toxic materials
	Use better quality resources and materials
Good Management	Plan production in such a way that a product modification at certain line requires no additional washing and cleaning quantities
	Improve maintenance – repair leaks and leakages
	Better production organisation and reduction of the washing frequency for machines and equipment
Reuse and Recycling	Recycle and reuse cooling waters and solvents
	Treat waste water and use it in the process or redirect it towards other customers
Technological Changes	Modify the production process, maximise closed cooling and heating water flows
	Install water meters and improve process control, install instruments for water level control to avoid overflows
	Optimise process parameters
	Apply mechanical cleaning prior to washing, install nozzles for pressure washing, use tanks with non-stick surface
Product Modification	Reshape the product to reduce its impact on waters during and after its use
	Prolong lifetime and use
	Use waste flow as byproduct

Wire drawing is a technological process which passes through several phases, with main phases including:

- preparation of wire surface for drawing;
- wire drawing;
- thermal treatment;
- surface protection (two lines for galvanisation);
- adjustment and packing.

The plant is supplied with water from public water supply system. This water has the characteristics and quality of drinking water. There is no adequate measuring either of water consumption per individual plants or discharge of waste water.

Data estimates on distribution of water consumption per plants are given below (Table 4.4).

Table 4.4 Water Consumption in Wire Production Plant, P-8

Inlet	Consumption	Unit	%
Public water supply system	121,472.0	m^3/year	100
Item	**Basis**	**KM/m^3**	**Total BAM**
Water consumption cost	121,472.0	1.82	221,079
Cost Location	**Consumption**	**Unit**	**%**
Production processes	85,030.4	m^3/year	70
Industrial cleaning	7,288.3	m^3/year	6
Hot water for heating	1,822.0	m^3/year	1.5
Cooling water	19,435.5	m^3/year	16
Cleaning of premises	1,822.8	m^3/year	1.5
Toilets, bathrooms	6,073.6	m^3/year	5
Outlet	**Consumption**	**Unit**	**%**
Discharge into the environment with treatment	25,509.1	m^3/year	21
Discharge into sewage system	19,435.5	m^3/year	16
Evaporation	3,644.1	m^3/year	3
Circular flow	72,883.2	m^3/year	60

Water productivity indicator is 14,5 m^3/t and refers to specific consumption that includes all consumers within the industrial plant, as there is no possibility for measuring by production processes. Use of specific values identified in other same technology plants is not possible as the literature reports on consumption per individual technological processes, expressed in the quantity of water consumed in relation to the surface of treated metal. Thus, for instance, Nordic-Council reports on consumption of 50 l/m^2 of galvanised surface (Nordic-Council, 2002), and French regulations referring to final metal treatment require consumption of 40 l/m^2, for 5 flushing phases (France, 2003).

Providing water productivity indicator analysis was not feasible by means of comparison with the indicator values recommended in the reference literature, due to the lack of data on the surface of treated metal construction, burden of production in financial sense was analysed instead. Consumption of water and energy burdens the product price with 120.7 BAM/t, making approximately 20-30% of the price of high-carbon and low-carbon wire. As galvanisation, among other technological processes in wire production, dominates in water and energy consumption, one of the lines for galvanisation, with the capacity of 1,665 t/year, was used for analysis of prevention measures applying possibilities. Aimed at rationalisation of water, gas and zinc consumption, certain technological, good management, and reuse measures were introduced (Table 4.5).

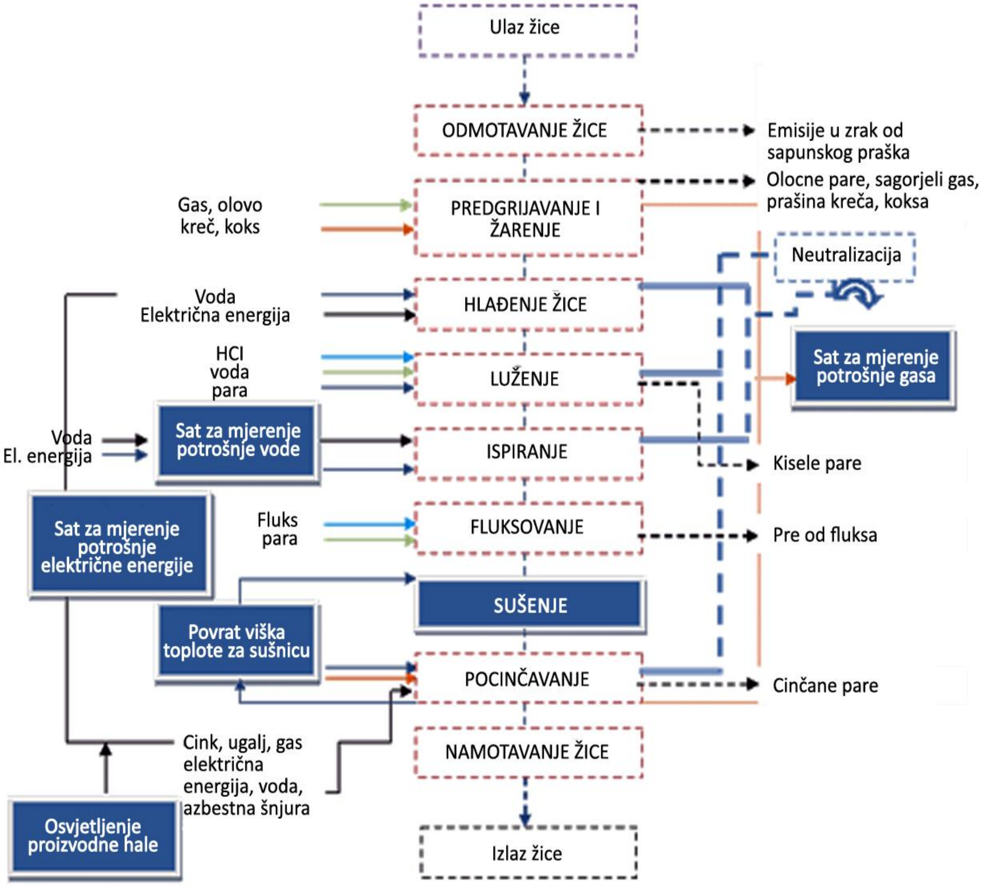

Figure 4.7 Schematic Overview of the Technological Process and Material Flows with Improvement Measures Aimed at Resource Efficiency, Wire Production Plant

Applying the measures above, the company managed to reduce water consumption by 72%, natural gas consumption by 10%, and the quantity of consumed acid by 51%, zinc by 57%, and lead by 31% within the period of one year, resulting in considerable annual savings of BAM 526,747 and immediate payback period.

Table 4.5 Overview of Prevention Measures Applied in the Wire Production Plant

Type of Measure	Description
Technological	Two gas metering devices and two water meters were installed on the galvanisation line. One gas meter was installed to measure gas consumption in the process of preheating and annealing, and the other in the process of galvanising. Water meters were installed to measure water consumption during flushing processes following pickling, and in the process of galvanisation.
Reuse and Recycling	Surplus heat from the zinc tub is used in the wire drying process, following oxidation prevention procedure in the oven.
Good Management	Monitoring consumption of other supplementary materials for rationalise their use to the best possible extent.

Following installation of metering devices, energy and water were meter continuously in the period of 15 days, and the identified consumption was 11,4 m^3/t. Galvanising process has been technically improved by installation of an additional pipe on surplus heat outlet line, above the zinc tub, changing the direction of heat emission from the atmosphere directly into dryers. Upon implementation of the prevention measures, a system for the management of resource consumption and cost monitoring has been introduced. Installed devices for metering consumption are read on the daily basis. Other measurements such as acid consumption, coal consumption, use of asbestos rope, are weighted. The data are recorded into the tables for monitoring consumption and costs, per cost centres (Omerbegović et al., 2006).

4.3.2 Sustainable Consumption in Settlements

Former proposition in operation of water supply systems was to provide continuous water supply maintaining the quality of water at an acceptable level to all consumers. It particularly refers to developing countries, where water is considered a social category. In order to satisfy their consumption demands, water utilities must gradually change their priorities: instead of constant expansion and opening of new sources, they turn towards internal reserves: reduction of losses within the supply network and reduction of irrational use of water by their consumers. Thereby, economic efficiency of water utilities is improved as well (Prodanović, 2003). Thus, the concept of a water utility operation must change from the old system of demand driven consumption to the system of demand managed consumption.

Table 4.6 Effects of Applying Prevention Techniques in Wire Production Plant to a Line for Galvanisation of1.665 t/year

Resource	Measuring Unit	Old Process			New Process		
		Total Consumption	Specific Consumption per Ton	Amount in BAM	Total Consumption	Specific Consumption per Ton	Amount in BAM
Water	m^3	18,981.0	11.4	49,350.6	5,334	3.2	13,868.4
Natural Gas	Sm^3	265,867.2	159.68	154,203.0	247,218	144.03	143,386.4
Acid	L	46,620.0	28	9,324.0	24,120	14.4	4.8
Zinc	kg	469,056.0	56	802,085.8	268,032	32	458,334.7
Lead	kg	142,392.0	17	176,566.1	46,068	5.5	57,124.3
Coal	kg	25,128.0	3	14,574.2	13,066.56	1.56	7,578.6
Lime	kg	16,752.0	2	2,613.3	10,721.28	1.28	1,672.5
Total Costs				**1,208,717.0**			**681,969.8**
Savings							526,747.1
Total Investment							1000
Payback Period							Immediate

One of key tasks of water utility companies, orientated towards sustainable water supply, is to reduce water losses. Apart from physical water losses within a distribution system, there are also administrative water losses, and losses of bad measurements. Administrative water losses refer to illegal consumption, lack of registration for all customers, and unmetered customer consumption. Losses at measurements are significant for produced/delivered water, as well as for consumed water. Water measurements at sources or measurement of produced water are very important. Knowledge of the total produced water represents major information for water utilities from several reasons. If the quantity of produced water is not measured, there is no way for water utilities to determine their efficiency in terms of the quantity of water supplied into their systems, assuming their customers are provided with regular metering. Measurements at sources represent one side of “inlet/outlet” equation enabling calculation of the quantity or percentage of total losses. Leakages caused by physical defects are only one of several possible components of total losses.

The quantity of total losses in water utilities may be fully determined only with existence of reliable data on the quantity of produced water (provided by accurate measuring instruments) and data on the quantity of customer consumed water (provided by accurate customer water meters). Following installation of water meters, their operation and required metering accuracy shall be maintained. It is necessary to produce data on all installed water meters, and identify the relation between the customer and the metering location. It is the only possible way to achieve accurate records of customers without water meters, noncalibrated water meters in certain time period, and inaccurate water meters. Upon that, it would be possible to carry out calculation of actual readings on accurate and calibrated water meters and make a good quality assessment of flat rate consumption for instances where water meters have not been installed yet or are were inaccurate.

Importance of reducing water losses in the system to a minimum cannot be overemphasised. A water utility must observe input of water into the system from the aspect of production, or a product whose production requires certain costs and thus has its value. In that sense, there is not much difference compared to the product of any other company, produced in a factory and then transported to final sale location. A company that produces such product expects to charge actual value for each produced piece, without losing certain percentage of the product value in its transport to the “market” and the final customer. Water, in that sense, shall not be differently treated.

A good example of resolving water losses has been given by public water utility JKP „Vodovod i kanalizacija“ Konjic that manages water supply and waste water disposal system in the city of Konjic in BiH, as well as three other separate water supply networks in neighbouring villages. Urban water supply system supplies 15.000 consumers, including households, industrial and commercial consumers, and public institutions, by means of approximately 5 km long main, half a meter in diameter. Water utility in Konjic had 60% of water losses, defined as a difference between the quantity of water delivered into the distribution system and the quantity of sold water. They set the target to improve the practice of water supply system management, aimed at achieving sustainable consumption. Water utility focused to the aspects below (IHGF, 2003):

- Institutional strengthening through forming and training of the leak detection team.

- Creation of water supply customer data base compatible with global information system (GIS), and water meter database, records customers and water meters.
- Creation of guidelines for measuring water intake, effective water consumption, water meter readings, identification of unmetered and unauthorised losses and staff training.
- Improvement of water supply management and reduction of physical losses, by means of the following activities:
  - creation of a model for calculation of water losses within the network;
  - procurement of a software for water distribution modelling;
  - detection of physical losses within the network;
  - installation of water meters for previously registered illegal customers;
  - reconstruction of water network per zones to enable measurement of the overall water flow.
- Preparation of the Plan for Reduction of the Unaccounted for Water (2003-2008) with general and specific annual targets, and activities.

During the first year of the plan implementation, losses were reduced by almost 70,000 m^3. Implementation of the programme resulted in the accomplishment of the following economic benefits:

- Reduction of operational costs for approximately 3,000 BAM per year (as the result of reduced water treatment);
- Increase of water sales revenues in the amount of 150,000 BAM per year (as the result of collection from industrial customers based on actual water consumption, and not flat rate collection, and by means of recording and metering water for all customers);
- Reduced demand for capital investments required for additional water intake to supply suburban settlements during summer months, with increased number of tourists. This technical solution requires capital investment of 15,000-30,000 BAM per l/s of the required additional capacity. Implementing these measures leading also to better management of water demands, there will be no more need for such investment.

4.3.3 Sustainable Consumption in Agriculture

Rational use of all available natural resources is the main principle of the so-called sustainable mankind development. In agriculture, one part of water is lost through the process of evapotranspiration and the other part flows to surface streams or ground water. Soil dilution is the most important carrier of biogenic, but also toxic chemical elements. Thereby, agriculture may become the cause of pollution of valuable water stocks.

Numerous irrigation means may be grouped into four methods, as follows:

- surface irrigation;
- ground irrigation;
- raindrip irrigation;
- localised irrigation.

Surface irrigation is the most commonly used and also the oldest method in the world. In case of this method, water overflows, floods the surface or resides in grooves and thereby dampens the soil. Disadvantages of this method that shall not be neglected include irrational water use, large earthworks, deterioration of physical characteristics and water-air relations in the soil, creation of thin crust, erosion, and similar. Therefore, surface irrigation shall be avoided whenever possible.

Ground irrigation is the method of supplying water through open canals or ground pipes, and then transferring it to the rhizosphere zone by means of capillary forces. This irrigation method is poorly spread due to specific application requirements such as soil permeability, flat terrain with the decline below 5‰ and natural watercourse proximity.

Recently, raindrip irrigation and localised irrigation are the most used methods in the developed countries. By means of raindrip, water comes through spray nozzles under certain pressure simulating natural rain, and thereby dampens the soil. Advantages of this method compared to surface and ground irrigation are manifested in the following: possible use in different topographic conditions, minimum preparatory works on the soil, it does not occupy arable land, it saves water, effect on physical soil characteristics are favourable and possible use of fertigation. Main disadvantages include price of facilities, operating costs, unequal distribution of water at strong wind and increased risk of plant diseases.

Localised irrigation consumes water most economically, as water is supplied under smaller pressure to the plot and then used to dampen only certain parts where roots are being developed. Apart from water saving, advantages of localised irrigation are manifested in the increased yield, reduced threat of siltation, possible use of chemical agents, restricted weed growth, reduced manpower need, and possible introduction of contemporary production procedures. Of course, this method has its disadvantages as well, such as price, possible damages of the majority of parts, but the biggest problem is the quality of water which often clogs droppers and thus leads to unnecessary costs of their replacement

(Barac and Bosak, 2003). Good practice in the management of water in agriculture, apart from irrigation techniques, includes:

- maximisation of water infiltration;
- adequate use of ground and surface waters, prevention of land drainage, improvement of soil structure and content of organic substances;
- use of treated waste water for irrigation purposes;
- adoption of a technique to control crops, quantity of water in the soil, time and quantity of irrigation and prevention of soil siltation, by means of maintaining convenient water regime and treating water, if needed;
- improvement of water cycle, securing permanent cover i.e. vegetation or maintaining or renewing soil moisture.

5

Financial Matters Related to Water Use

Integrated water resources management concept approaches water as an economic good. Namely, excessive and inefficient use of water by different users resulted in the acceptance of such approach by international environment and water management experts and its implementation within the integrated water management.

The idea of water as an economic good was the first time officially accepted and announced on the International Conference on Water and Environment held in Dublin in 1992 (ACC/ISGWR, 1992). One of four water management principles, adopted by relevant experts on the Conference above, is that: „Water has an economic value in all its competing uses and should be recognized as an economic good" (Principle No. 4).

With this principle, the Conference primarily emphasised recognition of basic human right of access to drinking water and sewage at affordable prices. Failure in recognition of the economic value of water in the past often led to profuse and economically adverse use of this resource. Management of water as an economic good is a way to achieve efficient fair use, and support to preservation and protection of water resources. Actually, this idea represented a compromise between two opposite opinions, the first opinion, mostly represented by economists, that water is a private good and shall be considered as all other private goods allocated through market defined prices, and the other opinion that access to water is basic human right that excluded from competition (Perry et al., 1997).

The Conference in Dublin held from 26th to 31st January, 1992 was attended by 500 participants, including experts from over 100 countries delegated by their Governments, as well as representatives of 80 international and nongovernmental organisations. It was recognised that global water resources have been critically threatened and, at closing, the Conference adopted the Declaration and the Report that emphasised perceived problems as current and with effects on man in immediate and not distant future, as well as possible effects on the survival of millions of people, thus requiring immediate and efficient action (ACC/ISGWR, 1992).

Economists have developed different attitudes on how to best solve the issue pertaining to the necessity to promote sustainable water use. Many participants in the water sector continue to believe that the access to water is an inalienable human right, a social need, and that water is a basis of stable and sound social and economic environment. However, there is also the opinion that water is a private good and shall be offered through a market game or competitive market prices (Lixia et al., 2006). It is also claimed in the same publication that Briscoe (1996), Perry (1997) and Hellegers (2002) clarified the distinction of treating water as „economic good“ from calculating tariffs and charging water. All those authors claim that observing water as an economic good is not primarily in the function of water tariff calculation, but rather in the function of defining the right choice in water distribution (similar is indicated in GWP, 2008).

Thus, the supporters of this attitude (that water is private good) consider water to be like any other good, and that its value shall be defined on the market based on the criteria of how much is a person willing to pay for it. Pursuant to such principle, water tariff shall be based on the water demand and actual costs of water supply. Such attitude fully neglects the fact on the existence of unequal ability to pay among the population and the fact that poor classes of population are often not able to pay the market water tariff, although it represents the main resource of living.

In contrast, supporters of the attitude that water is public good believe that water is the basic need and shall be available to everyone, in reasonable quantities and at reasonable or no prices. Furthermore, they believe that water supply shall be subsidised for endangered consumer, i.e. that they shall pay per reduced prices and the difference in price shall be covered by another consumer category (regulated by applicable government level). Nowadays, the majority of developing countries subsidises irrigation and water supply services, in the attempt to provide population with water and food supply, protect public health, and avoid protests of farmers or poor urban population against water tariff increases (Lixia and others, 2006).

The difference between actual “economic” and “financial” value of good shall certainly be mentioned. These two values rarely coincide, and in case of water, the difference is exceptionally complex and significant (e.g. Buna River spring presented in figure 5.1 below is one of the best yield sources in Europe; does it implicate the high economic value as well?). Thereby, it does not arise directly from the proclamation of water as an economic good that water shall be allocated to market mechanisms referring to financial, and not necessarily to economic, value (Perry and others, 1997).

Figure 5.1 Buna River Spring in BiH, among Best Yield Water Sources in Europe

Therefore, the aspect of water as an economic good has encountered numerous disagreements among water experts and economists that exist even today. There is the concern that the acceptance of the incorrect interpretation of the Fourth Dublin Principle may lead to extremely high water tariffs, which would, primarily, violate the rights of the poor, and then jeopardise the survival of certain business sectors, e.g. it would make irrigation fo agricultural land completely uneconomical. In order to avoid misuse of water for explicitly market purposes, water is stated to be a „social good“ as well. For example, Turton 1989 claims that water supply in past was often free of charge and that water was provided as a social good.

Nowadays, there is widely present interest and support of the idea of observing water as an economic good. However, the role of water as a basic living need, social, economic and environmental resource, substantially complicated selection of appropriate water tariffs (Perry et al., 1997).

5.1 Economic Principles of Sustainable Development and Water Management

Pursuant to Article 9 of the Water Framework Directive (EC, 2000), EU member countries are obliged to take into account the “cost recovery” principle in provision of services referring to water use and distribution to final consumers, including also environmental and resource costs (based on obligatory economic analysis conducted in line with the rules indicated in Annex III of this Directive), and particularly in line with the “polluter pays” principle. The principle, together with the “user pays” principle, is considered the economic principle of sustainable water development and management.

5.1.1 ”Polluter Pays” and ”User Pays” Principles, Cleaner Production

“Polluter pays” principle is based on the idea that the costs of environment pollution prevention and control, or costs of eliminating pollution, shall be covered by entities causing the pollution. It means that a water user (polluter) is obliged to pay certain fee for each water pollution in accordance with the level of the pollution caused. Furthermore, the user (polluter) is obliged to cover the costs of pollution cleaning and elimination, as well as the costs of damage occurring as a direct consequence of the pollution.

“User pays” principle is based on the idea that the entities using a natural resource shall pay all costs emerging from such use. There are several ways of using water resources that can and shall be charged, as follows:

- household water supply;
- irrigation of agricultural surfaces;
- use of water in industrial production;
- use of water in electricity production;
- recreational purposes, etc.

Water supply companies are usually entities that provide users with sufficient water quantities, and users pay remuneration which shall be in accordance with the “user pays” principle. Even in cases when consumers are provided with their own form of water supply, certain remuneration shall still be paid as they use natural resource owned by the the community.

“Polluter pays” principle may be shown on the following example – a factory in the production process creates and discharges substantial amount of polluted water, but the management is not ready to pay the costs of waste water treatment or does not have technical capabilities and capacities for the treatment. Therefore, the factory discharges untreated waste water into watercourses and thus retains the economic benefit as it saves on the treatment costs, but is hazardous to the society and the environment due to pollution of watercourses. The polluter shall, in a way, compensate the damage caused to the society and the environment, which is in practice most frequently pursued through payment of the pollution fee to be used by the administration, in charge of fee collection, for elimination of the pollution.

“Polluter pays” principle obliges the polluters to compensate the damage caused to the environment by their activities. In addition, this principle stimulates pollution reduction and introduction of best available environmental friendly practices into the production process. Furthermore, the same principle is applied to the population as well, to motivate construction of communal waste water treatment plant (examples of such treatment plants in France and BiH are given in figures 5.2. and 5.3. below)

The money collected through “polluter pays” and “user pays” principles is most frequently channelled to Environment Protection Funds (established in form of administration or bodies, agencies, department within ministries, etc.), to finance projects, programmes and similar activities in field of environment preservation, sustainable use, protection and improvement. Concurrently, the intention of this principle is to encourage water preservation and reuse, together with real water tariffs, as indicated in the Dublin Declaration (ACC/ISGWR, 1992).

Pursuant to Article 9 of the Water Framework Directive (EC, 2000), all EU member countries shall, upon applying the cost recovery principle, pay special attention to harmonisation with the “polluter pays” principle.

Based on the “polluter pays” principle, the cost of protection measures for prevention of water pollution are covered by the entity that may or already has caused water pollution. The principle should not be misused in sense of “pay and pollute” but shall rely on the prevention principle, or reduction of pollution at its source. Therefore, use of the “polluter pays” principle should not be interpreted in sense that the environment pollution is the right of those who are able and ready to pay for the damage caused. Investments into the treatment of waste waters should be more cost-efficient on a long-term basis than constant payments for the damage caused on the basis of the “polluter pays” principle.

Figure 5.2 Wastewater Treatment Plant Near Lille, France

From the long-term aspect, this principle shall be an incentive to the society to orientate towards the use of new environment friendly technologies. Introduction of new „cleaner“ technologies particularly refers to industrial polluters. Providing constant increase in industrial production, and thus the quantity of produced waste and waste waters, the “ability to accept” limits for individual recipients (watercourses) have been or may soon be reached in certain areas. In accordance with the integrated water resources management principle and sustainable development, it will be necessary to apply “cleaner technologies” in the production plants. Thereby, UNEP defined cleaner production in 1990 as: „The continuous application of an integrated environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment“. The definition is used nowadays in all programmes related to the promotion of cleaner production, with the intent to support:

- production efficiency, by means of optimising the use of natural resources (water, as well as materials, energy) in all production phases;

- environment management, by means of minimising adverse impacts of industrial production to nature and environment in general;
- human evolution, by means of minimising the risks to humans and their community, and supporting their development.

Figure 5.3 Wastewater Treatment Plant in Ljubuški, BiH

5.1.2 Cost-Recovery and Affordability Principles

Cost-recovery is defined as a measure within which production or service costs are fully covered by revenues – full cost-recovery is, in that sense, covering of the total amount of all costs of designs, production or services.

Concerning cost-recovery for water services, it refers to the recovery of water production and water supply costs, as well as waste water discharging costs, by means of revenues acquired through collection of user charges, or calculation of appropriate tariffs. Cost-recovery shall necessarily be achieved to ensure the quality of water and water supply and waste water discharge services, and the accompanying costs refer to maintenance and regular operation, depreciation and loan repayment, but shall also refer to environmental and resource costs, costs of increasing the level of services or number of customers, which is not always the case in practice.

The argument about water as an economic good is often used to justify the cost-recovery principle. Namely, in order to achieve economic viability of water supply and waste water discharge services, it is necessary to charge those services. Therefore, cost-recovery is achieved through water and wastewater tariffs or through combination of water and wastewater tariffs on one side and subsidies (financial support) by authorities on the other side. Based on the subsidy definition, subsidies may be expressed either as the total value of net public consumption or as the percentage of annual costs not covered by the collection revenues (Porter, 2002).

Water supply and waste water discharge services in the world, as well as in BiH, are provided by water supply or complex utility companies. Providing water is an economic and public good, it is most often considered for such companies that they shall not be substantially profitable companies. Nevertheless, in performing their activities, the company is burdened with business costs requiring collection of relevant revenues – the costs that shall certainly be covered include:

- Operational costs of water exploitation, treatment and distribution, as well as costs of collection, transport, treatment and disposal of waste waters. These costs include also the administrative costs.
- The costs of capital for new infrastructure, whereby the timeframe during which the capital investment is depreciated, i.e. written off, is of special importance.
- Costs of maintenance and rehabilitation of the existing property.

However, the contemporary approach confirms also the need of including the so-called environmental and resource costs – thus it is claimed in the first paragraph of the already mentioned Article 9 of the Water Framework Directive (EC, 2000) that: „ Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs …“.

Environmental and resource costs are not defined in this Directive, but refer mostly to the social costs of activities within which natural resources, such as water, are being exploited. Water has a very important social value, but often does not have a price, or its price does not reflect the actual value for the society. Environmental and resource costs represent the total economic value of the occurred environmental damage, which is the gap between current and good chemical and ecological status of a water body, including the economic value of the potential gain (opportunity cost) impossible to be implemented due to insufficient water for all desirable users. Part of these costs may be internalised through direct user costs (defined as „private costs“), ad the other part represents external costs (defined as „social costs”) (Brouwer et al., 2009).

Certain former research in BiH showed that the achieved revenues of water supply companies were not sufficient to cover their costs, even if 100% collection rate would be achieved (Alić, 2004; Speck, 2006), and the same research indicated a low collection rate in all 7 observed states (Albania, BiH, Bulgaria, Croatia, FYR Bulgaria, Romania, Serbia, and Montenegro).

The affordability of customers to pay for water services is of extreme importance. It does not mean that the costs shall not be covered, which would result in the non-sustainability of water services, but that the standard of services shall be set in such a way that the service is acceptable and financially affordable to the majority of customers. The affordability problem shall also be considered – 4% of average monthly revenues of a household has been internationally accepted as the upper affordability (Speck, 2006).

5.2 Economic Instruments (EI) in Water Management

Sustainable development implies achievement of economic development and improvement of the social welfare without jeopardising the environment. The most widely accepted definition is the definition offered by the World Commission on Environment and Development (WCED, 1987), which say that Sustainable development is the development that satisfies present needs, without jeopardising the possibilities for future generations to satisfy their needs. It is based on two main concepts:

- the concept of needs, especially basic living needs of the poor worldwide, and satisfying their need shall be the top priority;
- restriction idea pertaining to the existing technological and social organisation, as well as the ability of the environment to satisfy current and future needs.

Within global pursuit of profit, power and individual interests of the economic development holders, this objective is not always achievable. The population growth, urbanisation, GDP increase, and ever faster industrial development resulted in the situation in which the environment has become jeopardised and its quality seriously disrupted. The report „Living Planet 2010“ prepared by the WWF, the largest world’s nongovernmental organisation for environment protection (WWF, 2010), claims that, if it is continued with this degree of the development and exploitation of natural resources, even with the most moderate UN estimates of the World’s population growth, their average consumption, and climate changes, mankind will need the capacity equal to two earths by 2030 to absorb the emission of CO_2 and continue with this degree of natural resources exploitation. Reduction or suspension of such rapid disruption of the good environmental status surely requires the state intervention.

To support environment preservation, the state may intervene in two ways. Firstly, through legal measures or regulatory mechanisms, implying introduction of regulations and standards for water and environment preservation. The regulations, for example, defined the highest allowed concentration of pollution in waste waters, appropriate solid waste disposal, different prohibitions, etc. Such regulations are obligatory and mandatory.

Secondly, through introduction and application of market-orientated measures better known as economic instruments. Economic instruments in sense of integrated water resources management represent rules of rationalising or stimulations affecting allocation and distribution of water and water-related revenues. Water tariff, water rights, and water policies and regulations (pertaining to economic categories) are considered the most important economic instruments and their importance is assessed based on the impact on the efficiency, equity and environmental consequences in the society (GWP, 2008).

Economic instruments include, for example, financial mechanisms for motivation of polluters to reduce the risk of their activities to the environment and, generally, to human health. Economic instruments are applied to affect the awareness and change in the behaviour of polluters and users of natural resources, and concurrently collect revenues channelled to environment protection, or reduction or elimination of adverse pollution effects. They are applicable in different sectors: in water management, solid waste management, protection of air from contamination, soil protection, protection against noise.

In market businesses, the latter economic measures are more and more present as they are more efficient than the regulatory measures. Economic instruments are used to affect the behaviour of individuals and the overall economy, by means of fining poor and encouraging and promoting good practices. In order to achieve maximum effect on environment preservation, combination of the two both afore-mentioned types of state intervention is applied.

5.2.1 Characteristics of Economic Instruments

One of main objectives in the policy of environment and especially natural resources protection is to accomplish integration with different social and economic sectors and their policies, as it is the way to achieve best results in environment protection. Efficient means for the achievement of such objective are economic instruments that have the capacity of linking, for example, water sector, environment sector and industrial production sector. By applying economic instruments, it is possible to either support or impose the inclusion of the environment pollution, occurring as the result of activities, into the production costs. Therefore, state intervention for internalisation of such costs by means of regulatory measures and fiscal policy (monetary policy) is urgently needed. The costs of environment pollution, considered external costs, occur when the society or a community, whose environment has been disrupted, invest fund into the rehabilitation of the disrupted state of environment. It is certainly crucial for such costs to be transferred to the entities causing the damage.

What are the fundamental characteristics of economic instruments?

- Inclusion of the afore-mentioned external costs is the main reason of applying economic (environmental) instruments, instead of, for instance, regulations prescribing allowed pollution limits. It implies the attempt of incorporating the costs of environmental damages or costs of resources into the product price by means of economic instruments, aimed at mutual integration of external and internal costs. Thereby, internal costs represent direct costs of production of goods and services, and the external costs occur as a side effect of business activities, such as pollution costs and costs of other environmental uses. The better the relation between internal and external costs, the sooner will the environmental concern become a part of regular economic decision-making.
- Economic instruments provide incentives for manufacturers and consumers to orientate themselves towards environmentally friendly behaviour.
- Economic instruments enable achievement of more efficient and cost-effective pollution control than the application of restriction regulations only.
- Economic instruments may encourage manufacturers to apply innovative solutions with less adverse environmental consequences, including water resources. Upon taxation or collection of high pollution fees for discharge of hazardous substances into the water, paying manufacturers are encouraged to develop new production and consumption methods to reduce their tax and fee costs. It improves the development sustainability, but also the international competitiveness on markets that recognise environmentally friendly production, such as the EU market.
- Economic instruments result in the collection of revenues that may be directly used for improvement of the disrupted state of environment.

Economic instruments in the function of integrated water resources management represent rationalising rules and incentives affecting allocation and distribution of water or water-related funds and revenues.

Several types of economic instruments are applied nowadays, such as: fees for use of resources, pollution fees, product fees, charges for violation of regulations, and similar. It is certainly necessary herein to distinct charges (taxes) and fees – a charge is an instrument used by the administration to collect revenues directly into the general budget of the related authorities, while fees represent pre-specified purposes (e.g. environment protection) and are most frequently collected by companies, agencies or funds, as public administration bodies with clearly defined function, or even as private companies granted the concession to pursue certain function. Concerning economic instrument applied in water sector, their role is primarily to provide recovery of all costs of sector services, including external costs as well. Furthermore, these measures encourage efficient water use, as well as pollution reduction or elimination.

There are several main types of fees applied in water sector:

- **User fees** are payments of services provided to the population and business entities. Such services include, for example, water supply and waste water discharge. They are primarily used to cover the respective costs and maintain water supply and sewage services on the acceptable level. User fees include: water tariff, water abstraction fee, sewage fee. Pursuant to Article 9 of the Water Framework Directive (EC, 2000), EU member countries shall provide by 2010 such water tariff policy that will ensure appropriate incentive to consumers to use water efficiently and thus contribute to the environmental targets defined in the Directive. This category includes also fees for use of water in economy, e.g. in hydro-power sector, agriculture, mineral water production, and similar.
- **Water protection fees** are charged for discharging pollution into the environment and are based on the quantity and/or quality of the discharged waste water.
- **Violation fees** are payments imposed on polluters who fail to fulfill good environmental management requirements. These fees may be proportional to the selected variables, such as, for example, violation caused damages or profit from violation. These fees are also called fines or penalties.

5.2.2 Water Tariff in Water Supply

The largest water supply customers, i.e. consumers, are households, economy and agriculture. Although agricultural needs depend on rainfall, irrigation in average uses up to 70% of water in the world (illustrated in the figure below). However, water tariff in this sector is determined differently than for consumption in households and economy.

Water supply service providers, with few exceptions worldwide, charge certain fee to cover their costs. In developed countries, water tariff is higher, while in undeveloped and developing countries it is considerably lower, reflecting itself the fact that water tariff is often a subject of (political) agreement and is not always conditioned by respective costs of providing such services.

In its basis, water tariff is also an economic instrument aimed at covering all costs of the related service providing and belongs to the group of user charges. The target of this instrument is to make all consumers aware of the fact that water has its value. The value of water is reflected in different water uses.

Figure 5.4 Use of Water in Agriculture

Direct water supply costs mostly consist of fixed costs (capital and administrative costs) and in small extent of variable costs which depend on the quantity of consumed water (primarily energy costs and costs of chemicals). Consumers are often charged only a part of these costs, while the remaining part is funded through direct or indirect financial supports (subsidies) from local, regional or state authorities.

Water tariff is usually calculated per m^3 of consumed water, implying that the consumer is provided with a water meter used to measure consumption. Apart from the price per m^3, a fixed part of the tariff which does not depend on the quantity of consumed water but shall cover the costs of water meter maintenance and reading, calculation of a water bill and invoicing are sometimes billed and charged as well. If accurate measurement of the consumed water is impossible, i.e. if the consumer does not have a water meter, the cost is based on the amount depending on, for example, the number of household occupants, surface area of residential or business premises, etc.

In developed countries, same water tariff is often applied to all consumer categories, which is not always the case in undeveloped and developing countries. Namely, frequently applied is the so-called cross-subsidising of consumers, whereby one category, e.g. economy and commercial consumers, pay higher water tariff, and another category, e.g. households, pay lower unit tariff, with the first category subsidising the lower tariff for the latter category. Such different tariffs are supported either by the state's social policy or the attempt to support the development of the economy (opposite use of tariffs than afore-mentioned).

Tariff calculation based on service providing costs means establishment of a cost-covering tariff, i.e. tariff by means of which a water supply company will achieve revenues to cover the costs of daily operation and maintenance, as well as at least one part of investment costs. On the other side, cost-covering water tariff is also a measure for protection of water as a natural resource, as the tariff is used to orientate consumers towards water saving. Too low tariffs may incorrectly reflect water as an inexhaustible natural resource. Water tariff affects also the introduction of new technologies into the economy, including treatment systems and re-use of water, concurrently reducing the quantity of waste water discharged into the environment.

Strictly applying the cost-recovery principle, it could be stated that water supply and waste water discharge tariffs are different for each individual consumer. However, due to practical reasons, service users are most frequently grouped into appropriate categories, based on dominating user characteristics. The prices of these services in principle distinct from one to another consumer category, providing there are differences in costs generated for each service. In principle, calculation of water supply and waste water discharge tariffs is carried out in below listed steps (phases):

- calculation of required annual revenues for the period during which the tariffs will be effective;
- distribution of service costs to main functional cost components;
- distribution of service costs to individual consumer groups or categories;
- calculation of the actual tariff system for all consumer categories that will create revenues for a water utility matching the costs of providing services to different consumer categories.

Two most frequently used methods for calculation of required water utility revenues include:

- method based on required funds;
- method based on engaged capital assets.

Regardless of the method applied, tariffs are calculated for the related planning period, based on historical accounting and other data and business plans. The duration of the planning period depends on several factors, with the most important ones including:

- Macroeconomic system stability, primarily from the aspect of inflation. In case of high inflation, service price shall be planned for shorter period of time, best for one year. There are also other economic factors that may affect reduction of the planning period, including primarily increased minimal labor price, and increase of energy (electricity and oil), materials and equipment prices.
- The growth of the water consumption scope. In cases when the growth of the consumption scope is expected, either due to the increase in the number of consumers or due specific consumption increase, the planning period shall be shorter.
- Reliability of available data used as the basis for the cost assessment. In cases when planning is based on unreliable historical data, planning assessment are relatively unreliable, thus the planning period shall be the shortest possible.

Method based on required funds is based on the above indicated assumption that revenues must cover all financial needs of a company. Required revenues, calculated by means of this method, include all liabilities of a company resulting from its operational activities. There are two main groups of costs, such as operation (comprehensive knowledge of operational costs requires also a good overview of network, as presented in the figure below) and maintenance cost, and capital costs.

Figure 5.5 Example of Water Supply Network

Operation and maintenance costs include costs of salaries and other benefits, electricity costs, costs of fuel and lubricants, costs of chemicals, costs of stationery and other consumables, costs of services to third parties, rents of premises and services, salary taxes, fees and services, and other costs related to operational activities of a water supply company.

These costs are calculated based on historical accounting data on one, and business plans on the other side. Accuracy in their assessment depends on the specificity and functionality of the accounting data, as well as business plan analyticity and reality.

Capital costs include loan servicing costs, referring to the amount of cash needed to repay the principal and interests, as well as other loans resulting from the capital development of the company, including capital development costs, funded from current business activities and/or depreciation. Capital costs are usually related to the following types of investments:

- replacement of existing facilities and equipment;
- regular extension and improvement of facilities and equipment;
- capital investments into new facilities and equipment.

First two types of capital expenditures are usually funded from current revenues or depreciation. Capital investments into new facilities and new equipment are usually large in scope and thus cannot be funded from operational revenues of a company. Therefore, they are most frequently funded through loans. Loan debts are repaid during a number of years, by means of allocating capital costs based on respective level of utilisation of the facility or equipment during their lifetime. This way of funding capital investment results in better adjustment of service prices in individual years to the actual use, ensuring that the capital development burden of a company is not fully at the cost of current consumers, providing the facilities will be used by future generations as well. A part of capital investments into new facilities and new equipment may be funded from current revenues of a water utility as well. In that case, the costs of such investments are included as a constituent part of required revenues.

Method based on employed capital assets is used in some countries, such as for example USA, for calculation of service tariffs in case of private, but also partly public, water supply companies. It is especially often applied in cases when services are delivered to consumers outside the basic supply area. An example is the delivery of water from one to another company owned by different local communities. This method is based on the principle that gains from employed capital assets are included in the company revenues. This is the gain on one part of fixed assets of a water utility used for provision of water supply and waste water discharge services. For public companies, total annual required revenue, in an ideal case, should be equivalent, regardless of which one of the two methods has been used.

For public companies, total annual required revenue, in an ideal case, should be equivalent, regardless of which one of the two methods has been used.

Concerning distribution of service costs to components, the initial basis is that different consumers have different requests in terms of the scope and the level of services to be provided by a company. Basic principle in calculation of water supply and waste water discharge tariffs is that the costs of providing these services are at the account of consumers, or a consumer category, the costs have been generated for. For the purpose of equitable distribution of costs to consumers, it is necessary to take into account the consumer requests in terms of quantity and head consumption, and thus proportionally distribute the costs. For example, for a consumer with high coefficient of consumption nonlinearity, it is necessary to provide larger diameter pipes, higher capacity pumps, and larger reservoir capacity, compared to a consumer with lower coefficient of nonlinearity but equal average consumption. Therefore, cost distribution methodology shall recognise specific consumer requests, such as total consumed water quantity, head consumption, and other factors. In the world’s practice, most commonly used methods for distribution of costs to functional components include:

- basic and extra capacity method;
- delivered and demanded quantity method.

Regardless of the distribution method, it is necessary to distribute operational and maintenance costs on one side, and capital costs on the other side, to applicable functional components, considering each cost item separately.

Development of a tariff structure is the final step in calculation of water supply and waste water tariffs. Upon the tariff structure development, it is necessary to take into account elements such as equity in distribution of service costs to consumers, or consumer categories, as well as local and other conditions, all aimed at satisfaction of company and consumer demands. Deviation from the cost-covering principle is possible, and it most frequently occurs due to political, legal, social or other reasons. However, such tariff structures shall be avoided whenever possible.

There is a larger number of tariff structure forms – certain most commonly used forms are presented below.

5.2.2.1 Tariff Structure with Single Tariff per Consumed Quantity, without Fixed Tariff

In case of these structures, there is a single tariff per m^3, independent of the quantity of consumed water. Single tariff is applied to all consumers, regardless of the consumer category. Factors such as consumption nonlinearity or size of water meters are not taken into account upon tariff calculation. Tariff is calculated by means of simple division of total required revenues with the total estimated water consumption. This structure is most frequently used in small systems, whereby customers have similar requests, and thus there is no need for a more detailed analysis.

5.2.2.2 Tariff Structure with Single Tariff per Consumed Quantity, with Fixed Tariff

As in case of the preceding tariff structure, the tariff is given per unit of water quantity, and does not depend on the total consumed water, but is given as a single tariff (one tariff block). This tariff is different for different consumer categories. Apart from the part calculated per consumed water, there is the other part for covering costs independent of delivered water and related to consumer costs. It is the part often called fixed tariff.

There are two variants of this tariff structure. Based on the first variant, fixed tariff includes only consumer costs, i.e. costs independent of the consumed water quantity, and existent regardless of whether water is consumed or not. Based on the other variant, fixed tariff, apart from consumer costs, includes also the costs of the delivery of certain, relatively small water quantity, while all other consumption is calculated per m^3.

5.2.2.3 Tariff Structure with Single Tariff per Consumed Quantity but different for different consumer categories, without Fixed Tariff

Another tariff structure based on the tariff per unit of consumed water (currency /m^3), whereby the unit price does not depend on the total consumed water (one tariff block), but in this case, there is no special charge for covering costs independent on the delivered water quantity (consumer costs). Tariff per m^3 is different for different consumer categories, and includes consumer costs (water meter reading and maintenance costs, and invoicing costs).

5.2.2.4 Flat Rate Tariffs

Flat rate service tariffs are introduced for service users not provided metered consumption, from whatever the reason. The amount payable (flat rate) is thus calculated on the basis of assessable elements, such as the surface area of a flat, number of rooms or number of taps within the flat, but most frequently based on the number of household occupants. This method should be avoided, providing it does not lead to cost-effective use of services.

5.2.2.5 Tariff Structure with Two or More Tariff Blocks

In case of tariff structures with one tariff block, there is a single tariff per m^3 of water, regardless of the total quantity of used water. However, it is possible to develop a tariff structure with two or more tariff blocks, with gradual change of tariffs, depending on the level of total consumption.

First step in definition of tariff blocks is the calculation of their margins, made based on the distribution of average consumption for each category – tariff block margins are defined in a way that a single tariff block includes major part of one or more consumer categories. Tariff structures with two or more tariff blocks may be structured in a way that tariffs within tariff blocks have descending or perhaps ascending form. The descending character is caused by the reduction of average service providing costs per m^3 following the increase in water consumption, providing consumption nonlinearity has the descending tendency. In that case, the majority of costs belong to basic consumption, and minor part of costs belongs to head consumption, thus the costs of consumers with lower consumption are higher. However, most commonly developed is the tariff system with ascending tariffs, targeted at water saving, and particularly applicable to companies with major problems in the quantity of water available for water supply. Following the adoption of the margins of tariff blocks and adoption of tariffs, it is certainly necessary to check whether the adopted elements provide revenues sufficient to cover total service costs on one side, and distribute the costs to individual consumer categories, on the other side.

5.2.2.6 Tariffs Based on Marginal Costs

Marginal costs are the costs of production of additional unit of product. Concerning water supply, marginal costs are related to the costs of increase in the total water supply capacity through construction of additional facilities. Taking into account the theory of increasing marginal costs, the costs of provision of every subsequent quantity are higher. Thereby, consumers are given a respective signal on actual water price, which may affect their demand for additional quantities. Although based on sound economic principles, the use of this theory is rather impractical for this type of services. Namely, tariffs developed based on marginal costs may result in considerably higher or lower revenues than needed, and thus are rarely used.

5.2.3 Water Use Fee

Water use fee represents the amount paid for exploitation of surface or ground water for different uses – e.g. water for public water supply, water and mineral water used for water bottling, water for irrigation, water for breeding fish in fishponds, water for industrial processes, including thermal power plants, and similar uses. This serves to control use of water resources and discourage possible over-exploitation of water resources.

The payers of the water use fee are legal or physical entities (e.g. water supply companies, business entities providing water supply from own sources and for own need, etc.), performing exploitation of water resources, whereby the fee is calculated for the quantity of exploited or used water. This fee may have explicit environmental dimension, providing revenues collected by means of it are channelled to environment protection. Revenues may also be used for research, surface or ground water resources management, or, for example, for compensation of damages occurred due to reduction of the ground water level.

Exceptionally, the fee for water used in fish breeding may be calculated based on the kg of produced fish (an example of a fishpond is presented in the figure below), and the fee for water used for production of electricity by means of hydro energy may be calculated based on the produced electricity expressed in kWh.

Figure 5.6 Fishpond at Bilećko Lake, BiH

5.2.4 Wastewater Discharge Fee

Waste water is polluted water which occurs after the use of water in households, by business consumers, in industry and agriculture, including domestic, urban and industrial "liquid" waste collected and discharged through a sewage system. These waters are thereafter discharged into watercourses, lakes or sea, with or without prior treatment. If untreated, waste waters may have considerable impact on the quality of the environment, as well as human health.

This service primarily implies existence of the constructed sewage network, followed by regular network operation and maintenance. Sewage network construction requires substantial financial investments, while its maintenance requires provision of lower but regular funds. Such funds are collected through the tariff/fee for the discharge of waste water.

Providing the quantity of water discharged into the sewage system is not measured in most cases, the fee is calculated on the basis of used water, i.e. waste water tariff is calculated based on water consumed by a customer.

5.2.5 Water Protection Fee

Contamination or pollution of waters or water bodies is often caused by human activities, and may be hazardous to the wildlife that either lives in water or depends on it, but also hazardous to human health.

Water protection fee is the fee charged for the discharge of waste water into watercourses thus causing pollution. This economic instrument is in the direct relation with the „polluters pay" principle and may be defined as the price paid for use of the environment as waste waters are discharged into the environment. This fee, as a special type of environmental fee, shall reflect all financial and economical, direct and indirect, costs of discharging waste water into the environment, or pollution, and the fee amount shall not be less than the costs an obligor pays for treating such water. The amount of the water protection fee shall:

- reflect costs to the environment occurred due to the contamination with waste waters;
- shall be sufficient to stimulate investments into the pollution reduction;
- generate sufficient revenues to cover the costs of purification measures.

The purpose of this economic instrument, apart from revenue collection, is to encourage polluters to reduce the quantity of discharged waste water, as well as to reduce the concentration of hazardous substances in waste waters.

Payers of the water protection fee shall include all legal entities and citizens involved in economic activity, as well as households that discharge their waste waters into sewage systems or their own sewage network, water courses, accumulations, underground, or other recipients or that, upon performing their activities, discharge waste water to agricultural, civil or forest land, thus directly or indirectly contaminating water.

The basis for calculation and payment of the water protection fee is often the unit of contamination, the so-called population equivalent (1 PE) calculated as 24-hour discharge of waste water based on: (i) the quantity of discharged waste water, (ii) the degree of its contamination and (iii) prescribed recipient category. However, the basis can also be 1 kg of fish produced in fish ponds, or 1 kg of artificial fertilizers or chemicals used for the protection of plants.

The basis for the fee calculation can also be the actual quality and quantity of waste water, calculated based on the conducted monitoring or information on the product output, level of waste water treatment, and the number of employees of a company that discharges waste water (flat rate may also be applied).

The funds collected by means of the water protection fee are intended for financing water protection activities and investments into the construction of new water protection facilities (waste water treatment plants).

5.2.6 Fee for Materials Recovered from Watercourses

Entities responsible for calculation and payment of the fee for materials (sand and gravel) recovered from watercourses include legal entities and citizens performing extraction of such materials from watercourses based on granted approvals. This is also the activity that comes under water management as it disturbs natural waterbeds and changes water regime. Applying this fee, revenues are collected and intended for investments into the environment enhancement. The fee is most frequently calculated as per the quantity of materials recovered from watercourses (in m^3).

5.2.7 Fee for Protection against Floods

This fee pertains to the protection of agricultural, forest or civil land, protected by means of appropriate flood protection facilities. The fee amount may vary, depending on the type of the protected land, and is mostly calculated per 1 ha of the protected land.

This fee pertains also to the protection of residential, business and other buildings protected by means of flood protection facilities, whereby the fee is calculated per 1 m^2 utilised building area.

5.2.8 Other EI in Water Management

Apart from the afore-mentioned, the most applied economic instruments in water management include also: irrigation fees, fees or fines for violation of regulations, subsidies, tax relieves, and other instruments.

Irrigation fees are paid for use of hydromelioration systems, i.e. systems for irrigation and drainage of agricultural surfaces. It refers to fees that may include several subtypes, depending on the service provided by means of such system, as follows:

- land drainage fee;
- land irrigation and drainage fee;
- water supply fee.

Irrigation and dewatering fees are fees paid for use of installed hydromelioration systems, while water supply fee depends on the quantity of water used for irrigation of agricultural surfaces.

Payers of these fees are all land users and owners who have directly or indirectly used irrigation and/or drainage, or all owners and users of the land supplied with water for irrigation purposes. The fee is calculated and paid per 1 m^3 of water, per unit of land surface and type of land culture.

Irrigation fees are very important economic instrument in provision of the sustainability of irrigation systems. They shall be applied in the amount that ensures cost recovery to irrigation service providers.

Fees for violation of regulations consist of fines imposed on the excess of allowed limits (e.g. concentration in discharged waste water). These fees shall be related to the level of allowed limit excess, whereby they are applicable to the unit in which the limit has been exceeded, or can be calculated on the basis of the ascending scale, whereby the fee amount increases with the increase of the allowed limit excess.

Subsidies may be direct or indirect. Direct subsidies may be defined as direct funding from public administration (the so-called monetary supports) in introduction of new technologies and good practices into the economy, to reduce environment pollution. An example of direct subsidies is the introduction of a water tariff that is below the level of cost-efficiency, with the difference in tariff paid to the water supply company by public administration authorities (local, regional or state authorities). An example of internal cross-subsidy is when one customer category is charged higher water tariffs to cover the lower tariffs imposed on another customer category (e.g. households, on account of higher tariff for business entities, as already discussed in section 5.3.3).

Tax relieves are applied to business entities and are also a type of indirect subsidies, whereby the industries are relieved from taxes and duties or charged reduced amount of taxes and duties for the development and introduction of the so-called “cleaner technology “.

6

Legal matters in water management

Water management in BiH is considerably affected by the international surrounding with the documents referring to water sector. Certain documents have the character of ratified international conventions, and as such are obligatory to the state, while other documents have the character of guidelines or recommendations. All those documents create significant legal, organisational and management frame and regulation of water management in BiH shall be pursued within it. Listed obligations stem from grouping BiH into the following groups of countries (ZZVB, 2006):

- Member countries of the United Nations Economic Commission for Europe (UN ECE);
- Danube River basin countries;
- Sava River basin countries;
- Mediterranean countries;
- Groups of countries in the process of joining EU, obliged to gradual adjustment of their decisions and documents to the directive applicable to EU member countries during the joining process.

Key guidelines of the documents relevant to water management in BiH are given below.

6.1 Helsinki convention

Although the European Committee has dealt with water protection and management since 1960's and adopted the European Charter on Water Resources as early as 1968, first regional convention in Europe concerning waters is the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992). Signing parties to the Convention have agreed to prevent, monitor and reduce each adverse transboundary influence. In that sense, the parties have committed to prevent and monitor contamination at the very source, as well as to secure rational and equitable use of watercourses, thereby guided by the precautionary principle, the polluters pay principle, and the principle of preservation of abilities for future generations to meet their needs. The Convention predicts a whole system of permitting for discharge of waste water into watercourses, execution of the environmental impacts assessment, preparation of emergency action plans for accidental cases, obligation to observe (monitor) condition of transboundary watercourses, cooperate in scientific research and exchange information.

Helsinki Convention is a frame convention which obliges the parties to it to sign bilateral and multilateral agreements to elaborate all issues accepted by the Convention, and to adjust the existing agreements to the Convention. In addition to the Convention, the Protocol on Water and Health was adopted in 1999.

BiH acceded to the Convention in December 2009.

6.2 Danube convention

The Convention on Cooperation for the Protection and Sustainable Use of the River Danube[4] is a regional convention signed in 1994 in Sofia. The objective of the Convention is achievement of sustainable and equitable water management consisting of:

- preservation, improvement and rational use of surface and ground waters within the basin;
- restriction of perils caused by accidents including substances hazardous to water, flood, and ice peril;

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[4] http://www.icpdr.org/

- contribution to the reduction of the contamination of the Black Sea from basin sources;
- cooperation in all water management domains.

Also in case of this Convention, basic principles are the principles of precaution and prevention leading to restriction and reduction of transboundary impacts in the domain of waters for both water regime components (quantity and quality), human health protection through sustenance of water quality in rivers and basin sources, as well as ecosystem maintenance and improvement.

Aimed at the achievement of the Convention objectives, International Commission for the Danube River Protection was established, as the main decision-making body. The Commission initiated a wide action for all signing countries to prepare water management plans for basins within the Danube basin. Water management plans must be adjusted to the European Union Water Framework Directive.

BiH ratified this Convention in January 2005[5].

6.3 Sava River Framework Agreement

Framework Agreement on the Sava River Basin[6] and the Protocol on the Navigation Regime were signed in Kranjska Gora on December 3, 2002 and amended in Ljubljana on April 2, 2004. Based on this Agreement and the Protocol, countries within the basin (BiH, Croatia, Serbia, and Slovenia) agreed to:

- establish international Sava River navigation regime;
- establish sustainable management of basin waters;
- undertake measures for prevention or restriction of perils and for reduction and elimination of adverse consequences, including flood, ice, and drought consequences and discharge of hazardous substances into the water;
- develop mechanisms for establishment of effective multilateral cooperation.

Framework Agreement on the Sava River Basin is a unique international agreement that integrates all aspects of water resource management and establishes

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[5] Official Gazette of BiH No. 1/05

[6] http://www.savacommission.org/

(joint) International Commission for Sava River Basin with the legal status of an international organisation for implementation of the Framework Agreement.

6.4 Barcelona Convention

European Union and 16 Mediterranean countries signed the Convention for Protection of the Mediterranean Sea or the so-called Barcelona Convention[7] in 1976 which was amended into the Convention for Protection of the Marine Environment and Coastal Region of the Mediterranean in 1995. Barcelona Convention, represents a legal frame for implementation of the Mediterranean Action Plan, created within the United Nations Environment Programme (UNEP) in 1975. The Convention has been supplemented with seven specific protocols to date:

- The Protocol for the Prevention and Elimination of Pollution of the Mediterranean Sea by Dumping (waste and other substances) from Ships or Aircraft or Incineration at Sea (from 1976, amended in 1995);
- The Protocol concerning Cooperation in Preventing Pollution from Ships, and, in cases of emergency, combating pollution of the Mediterranean Sea (from 1976, replaced with new protocol in 2002);
- The Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (from 1980, amended in 1996);
- The Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (from 1982, replaced with new protocol in 1995);
- The Protocol for Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf, and the Seabed and its Subsoil (1994);
- The Protocol on the Protection of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and Their Disposal (1996);
- The Protocol on Integrated Coastal Zone Management in the Mediterranean (2008).

Basic principles and obligations deriving from the Convention include:

- precaution and prevention principles through the assessment of environmental impacts of all water-related management decisions;
- principle “polluters clean and pay “;

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[7] http://www.unepmap.org/

- protection of ecological areas of special importance;
- provision of the approach to information concerning the state of the environment;
- reporting on emissions of contaminating effluents into water, air and on the ground.

BiH ratified the Convention based on succession in October 1994.

6.5 Guidelines and Recommendations

There is an array of documents for strategic decision making in water sector, which are at the level of non-binding guidelines and recommendations. The overview of documents and their key guidelines is given in Table 6.1.

Table 6.1 Documents at the Level of Guidelines and Recommendations

Conference	Key Guidelines
UN Conference on the Human Environment (Stockholm, 1972)	Recommendation to the governments of the EU member countries to form management bodies at the level of river basins and create efficient mechanisms for cooperation in field of water at the level of large river systems.
UN Conference on Waters (Mar del Plata, 1977)	Strategic guidelines: ▪ water intake shall involve payment of full economic costs, including also all costs of water and river basin protection; ▪ necessity for multiple use of water resources and application of all measures, especially economic measures, to ensure rationalisation of water consumption; ▪ integral solutions in the domain of water use, and protection of and against waters; ▪ time wise, priority is given to water management planning over other types of planning in space.
Dublin Conference (Dublin, 1992)	▪ water is an economic category and shall be treated as economic good in all forms of its use; ▪ water management shall be based on the participatory principle, especially including women, planner and decision maker at all levels; ▪ river basin is a water planning and management unit, with emphasis on the importance of establishing institutional forms of cooperation to enable coordination of

	water management at large basin levels within more states.
UN Conference on Environment and Development (Rio de Janeiro, 1992)	Agenda 21 was adopted as the result of the Conference as a collection of around 2500 recommendation for global sustainable development. Crucial for water sector is Chapter 18 concerning fresh water management, whereby management integrity in the foreground: management at basin level, multisectoral approach to water management encompassing all social, economic and development goals, environment protection goals, and goals of all other space users. It is recommended to all governments to develop national action plans for sustainable development of the water sector and implement them by 2025.

(Source: ZZVB, 2006)

6.6 EU Legislation in Water Management

Aimed at water and environment protection, EU legislation was established during the last 30 years which nowadays consists of over 300 legal acts, including directives, bylaws and decisions. Based on scope, this legislation has grown to 1/3 of the overall EU legislation. It has 8 sectors: horizontal, environmental air, water, waste, radiological protection, chemicals, and GMO, noise and nature protection. In addition, a large number of statements, recommendations, opinions and other political documents relevant to EU policy on water and environment have been published.

The fundamental of the European policy in field of waters is the Water Framework Directive (Directive 2000/60/EC) adopted by the Parliament and the EU Council of Ministers in September 2000. The Directive sets the framework performance of the EU in field of waters, especially surface waters, estuaries, coastal waters and ground waters. Main objective of the Directive is achievement of the good state of waters by 2015 implying below listed tasks:

- undertaking measure for prevention of the deterioration of surface water conditions, and achievement of a good state of such waters;
- maintenance of good ecologic potential and good chemical state of waters for artificial and heavily modified water bodies;
- progressive reduction of contamination with priority substances resulting from emission or dissipation of hazardous substances, as well as termination or gradual exclusion of the emissions of hazardous substances from the priority list;

- implementation of measures for prevention or restriction of ground water contamination;
- provision of balance between ground water extraction and recharge to achieve good status of the referred waters.

Prevention of further degradation of the quality of all waters and long-term protection of available resources are ensured through implementation of the measures below:

- waters are managed at the level of water region which implies a set of individual basins;
- determination of characteristics of each water region-district (district means region encompassing one or more river basins together with the pertaining ground waters and sea-shore);
- monitoring chemical, ecological and quantitative state of surface and ground waters of each water region;
- monitoring of protected regions within each river basin;
- programme for measuring pollution, including obligatory and periodical measurements;
- inclusion of all listed factors into the river basin management plan;
- public review of the management plan.

The principle promoted also by the European Water Charter is that management of water resources shall be pursued within basin, and not within administrative and political boundaries. In determination of characteristics of each river-basin district, member countries shall include:

- geographic and geologic characteristics;
- hydrologic characteristics;
- demographic characteristics;
- use of land and economic activity within the district.

By entering into force, the European Union (EU) Water Framework Directive set the framework defining basic principles of sustainable policy for management of waters in the EU.

In addition to the Water Framework Directive, the EU enacted a number of other directives concerning waters, with some of them listed below[8]:

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[8] http://europa.eu/legislation_summaries/environment/water_protection_management/index_en.htm

- EU Drinking Water Directive (98/83/EC);
- EU Directive on Surface Water for Drinking Water Abstraction (75/440/EC);
- EU Directive on Measurement and Sampling of Surface Waters (79/869/EC);
- EU Graundwater Directive on the protection of groundwater pollution caused by certain dangerous substances (2006/118/EC);
- EU Directive on Nitrates from Agricultural Sources concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EC);
- EU Directive on the Quality of Fishing Waters (78/659/EC), Shellfish Waters (79/923/EC), Bathing Water (76/160/EC), and Protection of Groundwaters against Contamination with Specially Hazardous Substances (80/68/EC);
- EU Directive on Dangerous Substances concerning pollution caused by certain dangerous substances discharged into waters (76/464/EC);
- EU Urban Wastewater Directive (91/271/EC);
- EU Directive on Protection of Water against Pollution with Agricultural Nitrates (91/676/EC);-izbrisati ponavlja se
- EU Directive on Assessment and Management of Floods (SEC 2006, 66).

The objective of the Directives is to ensure sustainable use of water resources in the EU, including good status of surface and ground waters from the aspect of environment, quantity and quality, defining quality standards for general surface and ground waters, as well as for specific purposes (e.g. for drinking or recreational swimming), emission standards for certain polluters (e.g. nitrates or hazardous substances) and technological standards, e.g. communal wastewater treatment, etc.

The Directives on assessment and management of flood risks, ground waters and pollution of aquatic environment with hazardous substances wrap up the legislation on waters in the EU, with the Water Framework Directive as its basis, and with which they make a unique whole. Later, in June 2008, European Parliament and the European Commission adopted the Marine Strategy Framework Directive (2008/56/EC). The Directive, for member countries, establishes the frame for implementation of necessary measures aimed at achievement or sustenance of good environmental status in the marine environment, latest by 2020.

Approximation of the national legislation is a single obligation of the EU membership and nowadays is considered the most important step in constitution of water management in BiH. It means that the countries aiming to join the European Union must adjust their national laws, other regulations and procedures in a way to include the overall EU legislation contained in the *acquis communautaire*[9]. This integration process, or incorporation of the EU laws into national legal systems, is known as *the process of approximation or convergence to the European Union legislation*. Main objective of such process is to ensure complete harmonisation of environmental legislation and the related administration system, to make it fully compliant with the EU legislation requirements.

Three key elements in adjustment of local environment-related legislation to the EU legislation include:

1. ***Transposition of legislation*** – The state must adopt new or modify the existing laws and other regulations in a way to make them compliant with the EU legislation, or provide complete incorporation/inclusion of the EU principles and standards into the national laws. The process is known as **transposition**.
2. ***Implementation or use in practice*** – Meaning that it is necessary to establish institutions and ensure funds required for the implementation of laws and regulation. It is the implementation phase – implementation or application of the directives.
3. ***Execution of laws*** – Meaning that it is necessary to ensure control and sanctions required to provide complete application and respect of laws and other regulations (force measures). Since 1990, this has become a very important factor as poor execution of laws in some member countries prevents execution of EU policies on human health and environment protection, as well as joint market policy.

Principles and provisions of the related Directives concerning waters have been built into our legislation through Water Law and accompanying rulebooks.

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[9] ACQUIS COMMUNAUTAIRE is a phrase used for all principles, policies, laws, and objectives agreed within the EU and includes all legal acts – directives, regulations and decisions adopted based on different treaties representing main law of the European Union and the Community.

6.7 Water Law of the Federation of Bosnia and Herzegovina, Republic of Srpska and Brčko District

In order to achieve harmonisation with the water-related EU Directives, principally, EU Water Framework Directive, Convention on Danube River Protection and MAP (Mediterranean Action Plan), Bosnia and Herzegovina has implemented a number of activities directed towards water management based on two key principles, as follows:

- Organise management of water resources on the river basin level applying the principles of integrated water resources management;
- Prevent further water degradation and achieve “good status” of waters.

One of the activities in that sense was the adoption of the new Water Law in both entities. In the FBiH, Water Law was adopted in 2008 through publishing in the “Official Gazette of FBiH” no. 70/06. In the RS, Water Law was adopted in 2006 through publishing in the “Official Gazette of the Republic of Srpska” no. 50/06. The principles of the EU Water Directive have been transposed into the listed laws. Water Law organises management of water resources on the river basin level, and sets also a new challenge within water sector, which is involvement of the public in the decision making process. Water resource management encompasses water protection, water use, protection against adverse water impacts, and regulation of watercourses and other waters. Institutional framework for issues related to water management and financing of this sector has been established as well.

Water resources management is based on the principles below:

- non-commerciality, based on which water essentially is not a commercial product, but heritage which must be preserved, protected and handled accordingly;
- integrities, considering natural processes and water dynamics, as well as mutual relation and dependence of water and water-related ecosystems;
- long-term quality protection and rational use of available water quantities;
- providing protection against adverse water impacts resulting from needs for population and population property protection, considering effects of natural processes;
- economic valuation of waters which includes costs of loading, protection and regulation of waters, as well as protection against adverse water impacts;
- public participation in adoption of water management plans;
- consideration of the best available technologies and new scientific achievements concerning natural legitimacies and best environmental practices.

The analysis of the conformity of local water-related legislation with four relevant EU Directives was conducted in 2006, as follows:

- Water Framework Directive 2000/60/EC amended by the Decision 2455/2001/EC;
- Urban Wastewater Directive 91/271/EC;
- Drinking Water Directive 98/83/EC;
- EU Directive on Nitrates from Agricultural Sources 91/676/EC.

The result for the level of the conformity of local legislation with the EU legislation stated in the European Commission report from 2007 is presented in Table 6.2.

Table 6.2 Level of Conformity of BiH Legislation with the EU Water-Related Directives

Directive	% of Conformity	% Non-Conformity
Water Framework Directive 2000/60/EC amended by the Decision 2455/2001/EC	83% (520 points out of possible 625)	17%
Urban Wastewater Treatment Directive 91/271/EC	0,7% (20 points out of possible 265)	99,3%
Drinking Water Quality Directive 98/83/EC	58% (90 points out of possible 155)	42%
Directive on Protection of Waters against Pollution with Agricultural Nitrates 91/676/EC	0,3% (5 points out of possible 135)	99,7%

(Source: EU Project Report „Monitoring Progress of Harmonising Environmental Legislation of Countries: Albania, BiH, Serbia, Montenegro and Kosovo with the EU Legislation“, 2006)

7

Socio-Economic Issues Relating to the Water Use

„Water is fundamental for life and health. The right to water is indispensable for leading a healthy life in human dignity. It is a pre-requisite to the realisation of all other human rights.“, The United Nations Committee on Economic, Cultural and Social Rights, 2002.

7.1 Water as Human Right

7.1.1 Right to Water and International Human Rights

Access to sufficient, safe and affordable water is crucial for the society development. The right to water is a right to access to the necessary quantities of water, whereby the access presumes the ability to pay (affordability), and sufficient quantity means quality and quantity of water to meet the basic human needs.

Several international documents, in an indirect way, suggest that the right to water is one of the basic human rights. For example, the Universal Declaration of Human Rights in Article 21 paragraph 2 states that: " Everyone has the right of equal access to public service in his country" (UN, 1948). Other similar documents also mention the right to life, right to optimal living conditions and everything that makes life viable, what includes right to water, as one of the basic requirements to sustain life. Explicitly and directly the right to water is cited in two of the six core human rights treaties, namely: the The Convention on the Elimination of All Forms of Discrimination against Women (UN, 1979) and the Convention on the Rights of the Child (UN, 1989), which are briefly presented in the Table 7.1.

Table 7.1 Relevant UN conventions related to water

Relevant convention	Significant terms
Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) Adopted with Resolution 34/180 of the General Council, 18 12.1979. and opened for signature, ratification and accession. Entered into force on 3.9.1981. (UN, 1979)	Article 14 2. States Parties shall take all appropriate measures to eliminate discrimination against women in rural areas in order to ensure, on a basis of equality of men and women, that they participate in and benefit from rural development and, in particular, shall ensure to such women the right:.... (h) To enjoy adequate living conditions, particularly in relation to housing, sanitation, electricity and water supply, transport and communications.
Convention on the Rights of the Child Adopted with Resolution 44/25 of the General Council, 20.11.1989. and opened for signature, ratification and accession. Entered into force on 2.9.1990.. (UN, 1989)	Article 24 1. States Parties recognize the right of the child to the enjoyment of the highest attainable standard of health and to facilities for the treatment of illness and rehabilitation of health.... 2. States Parties shall pursue full implementation of this right and, in particular, shall take appropriate measures:: … (c) To combat disease and malnutrition, including within the framework of primary health care, through, inter alia, the application of readily available technology and through the provision of adequate nutritious foods and clean drinking-water...

Of course, the human right to water exists because the water is generally recognized as a key element of life. However, this right has not yet been clearly and undoubtedly defined in international law and is not clearly recognized and declared as a fundamental human right. The right to water is therefore often interpreted as a component to be considered as part of existing human rights, and that its explicit underlining is thus unnecessary. However, today when the quality water is becoming increasingly scarce natural resource, especially taking into account climate change and its consequences for the planet, extracting right to water from the shadow of other human rights could contribute to its better protection.

7.1.2 Water Right Components

The right to water means that water must be of adequate quality and affordable, in a quantity that corresponds to the basic human needs. Therefore three basic components of the right to water may be distinguished:

- The availability of potable water, which includes:
    - Physical accessibility,
    - Affordability or ability to pay,
    - Legal accessibility zakonsku without any discrimination;
- Water quality;
- Water quantity.

Figure 7.1 The availability of water in the world is not equal

Accessibility. Physical accessibility means that the water is accessible within a reasonable physical range, which means it is accessible within or close to home. In fact, even today in poor countries, the water is accessible only in remote places, where the task of bringing the water to home is usually performed by women and children (as illustrated in the Figure), sometimes even risking their lives.

Affordability means that the price of water must be acceptable to the majority of population. In practice it is often recommended to limit spending 4% of total monthly household income for purposes of paying water supply and sewerage services, as recommended by the World Bank (Speck, 2006).

Accessibility without discrimination means that water supply and wastewater services must be accessible to all, including the poorest population. Given that these services are not provided for free, the state must ensure that their price is such that every resident has access to these services.

Water quality. The rapid economic development during the last century, which was not accompanied by adequate concern for environmental protection and natural resources in particular, has resulted in significant pollution of water resources of the Earth. The consequence is certainly restriction of the potable water supply availability, and even if people get enough water for drinking, it may be that the water is dangerous to their health. World Health Organization (WHO, 1993) in its guidelines in 1993. advised all countries to develop their own national standards and to provide safety of drinking water through the elimination or reduction of the minimum concentration of those constituents of water that can be hazardous to health.

Water quantity. Quantities of water should be sufficient to meet basic human needs, including water for drinking, bathing, cleaning, cooking and sanitary purposes.

Although other ways of using water, such as food production and industrial consumption, are also very important for achieving higher living standards, given that agricultural and industrial production require large quantities of water, these needs should to be settled only after basic human needs are met.

7.1.3 Access To Water and Affordability

The basis for the tariff setting process is the population ability to pay their share of costs for the good service, that will meet his expectations. Such expectations are different in different parts of the world and are often influenced by the previous practice - for example, if for a longer period water supply services were provided at very low tariffs or even for free, it is hard to expect that at short run consumers would agree to pay full costs for these services. Ability and willingness to pay must therefore be carefully assessed when trying to set the tariff, respecting the principle of full costs covering - one should take into account the previous practice of pricing, average household income level, the required quality of service, as well as all types and amounts of expenses that should be covered (Laredo, 1991).

Water price should be based on the concept of "ability to pay" (affordability). Ability to pay is depending on level of total household income and its sufficiency to pay a certain price for water supply and sewer services, still without jeopardizing the ability to pay for other life necessities.

To determine the ability to pay for water it is necessary to determine the fraction of the cost of water supply and wastewater services in the total average monthly household income - principally as an affordability limit this proportion is said that it should not exceed 4% (Speck, 2006). Water tariffs for the economy and tourism can also be subsidized and deliberately maintained at low level, in order to make them more competitive in the market, but it can lead to market distortions and distorted prices, so as to excessive water consumption.

Dublin Statement fourth principle (ACC / ISGWR, 1992) confirmed that the basic human right of access to water and sanitation includes ability to pay. The fact that water is not free natural resource, and that bringing water to home is only possible with costs. In addition, water is becoming more and more scarce resource because of the growing demand by different users, either due to the increase in population or due to economic growth and development.

Large population growth, intensive urbanization and economic development during the 20th century have led to multiple increases in water consumption for potable water supply and for the needs for sanitary and industrial usage. This increase in water consumption resulted in an increased amount of wastewater, which present a serious problem for human health and the environment, if the wastewater management is not done properly (UNEP/WHO/HABITAT/WSSCC, 2004). Diseases associated with inadequate water supply and sewage disposal are still of great influence to the general health conditions, especially in developing countries. For instance, in 2003 it was estimated that 4% of all diseases in the world and 1.6 million deaths associated with inadequate water supply and sewage disposal, so as with poor hygiene (WHO, 2003).

Taking into account all these problems, the United Nations declared period 1981-1990 as the international decade of water supply and wastewater services, aiming to secure access to at least elementary services for all the inhabitants of the earth till 1990. This goal was not achieved, since at the end of the 1990's more than 1.1 billion people had no access to organized water supply, and over 2.7 billion had no access to sewer services (Whittington et al, 2008). After this period, in the next 15 years, the number of people who have access to these services has increased by about one billion, but due to the increase in the total population on Earth, the number of people without access has remained nearly the same, 1.1 and 2.6 billion respectively (UNICEF / WHO, 2004).

Therefore in 2002 The World Summit on Sustainable Development in Johannesburg have declared a set of Millennium Development Goals, one of which is reducing by half the number of people on Earth who have no access to water and sanitation by the year 2015. UN Millennium Task Force has prepared a report on the achievements of the fulfillment of this goal in 2005 (UN Millennium Project), and progress is also monitored by Joint Monitoring Programme (JMP) of the World Health Organization (WHO) and UNICEF, and every three years World Water Development Reports are published, all of which indicates the high importance of this goal. The initial needs assessment for achieving this goal were revised and JMP in 2006 estimated that access to these services should be provided to as many as 1.5 billion people by 2015.

British Medical Journal (BMJ) in 2007 surveyed more than 11,000 of its readers on what would be the most important medical advance in the last 170 years and the majority thought it was a "sanitary revolution" - connecting households to water supply and sanitation, what was assigned greater importance then to e.g. discovery of antibiotics, vaccination or identification of the DNA structure. Such opinion is confirmed by the fact that it was the cholera epidemic in 19th century that led to the establishment of public sewer systems in London and New York, and afterwards in other parts of Europe and North America. After that, the disease in those cities never emerged again, while it continues to be a major "killer" in developing countries. World Health Organization in 2006 recorded even 236,896 cases of cholera with 6311 deaths in 52 different countries, what was an increase of 79% compared to 2005, or at the same level as in 90-ies of the last century (Hall and Lobina, 2008).

Water supply and sanitation services coverage in different parts of the world is quite different (Table 7.2). Part of the world with the lowest coverage level for water supply services is Africa, where about 38% of the population has no access to water supply. In terms of sewerage services, however, the coverage is lowest in Asia, where over 50% of the population has no access to this service. Highest standards are achieved in North America, where virtually the entire population has access to water and sanitation. In Western Europe about 92% of the population has access to sanitation, while the percentage of population connected to public water supply systems is even higher (96%).

Table 7.2 The coverage of water supply and sanitation services in different parts of the world

Part of the world	Service coverage (%)	
	Water supply	sanitation
Africa	62	60
Asia	81	48
Latin America and Caribi	85	78
Oceanija	88	93
Western Europe	96	92
North America	100	100

Source: WHO/UNICEF/WSSCC, 2000

The situation regarding the provision of these services In Bosnia and Herzegovina is significantly inferior to Western Europe. Thus, the public water supply systems cover only 56% of the population in FBiH and 48% in the RS (FBiH/RS, 2003). Provision of wastewater collection and treatment services is at an even lower level. Approximately 56% of the population in urban areas is connected to the sewerage systems (FBiH/RS, 2003), while in smaller settlements the coverage is estimated at less than 10%. The majority of waste water collected is discharged into water courses without any treatment, and only a small number of cities in BiH has wastewater treatment plants that are in operation (Čelinac, Čitluk, Gradačac, Grude, Ljubuški, Neum, Srebrenik Trebinje) or require serious reconstruction (Sarajevo, Trnovo). All this points to a significant risk to public health, especially with regards to the risk of infectious intestinal disease.

7.1.4 Willingness to Pay

Component to be taken into account when determining the water tariff and sanitation is "willingness to pay." Willingness to pay is represented by the amount that the consumer is willing to pay for the scope and quality of service. Willingness to pay is based largely on subjective assessment of the consumer's own financial capacity, as well as quality and price.

Therefore, the willingness to pay reflects the consumers' priorities when it comes to changes in the quality of water supply and wastewater services in relation to changes in the tariifs for these services. To determine willingness to pay for increased tariffs of services means to determine the percentage of consumers who are willing to pay increased prices if they would get better service.

A number of papers is written on the accesabilityt to potable water impact to health, but few focused on willingness to pay for potable water, which is very important determinant of whether or not water quality improvements lead to better health conditions. In the end, if there are no subsidies to water prices, efforts to improve the water services quality will be sustainable only if potential users of these services agree that the difference in the value of services is higher than the difference in costs. Studies have often been devoted to willingness to pay of water in less developed countries, but the focus before was more on quantity than on quality of the water, although both characteristics are intertwined (Kremer et al, 2009).

7.1.5 Water Tariff – Socially/Politically or Economically Defined?

Conceptual conflict when determining water tariif is whether it is economic (and thus market) or social category. The economically based tariff means that all costs incurred during the performance of these services should be fully covered. However, the establishment of adequate pricing of water can also mean a price increase that will overload the purchasing power of households, and would have especially negative impact to poor people. Thus it happens that the public administration (local, regional, state government) subsidies part of costs to water supply companies (mainly investment costs, while environmental and resource costs are mostly not even considered), so that people could pay affordable price for the water services - it is the part of the state social policy. Furthermore, the tariff can be and in practice is often cross-subsidized, where one category of consumers has a higher water tariff while the second category has a lower unit tariff, where actually the first category subsides the second one. These different rates are driven by government or social policy, or efforts to support development.

7.2 Water and Health

7.2.1 Availability of Potable Water in the World

The availability of clean water is one of the most important issues of humanity today, where this problem will even increase in the future - the growing demand for water exceeds supply options, while hazardous waste materials are increasingly polluting both the groundwater and surface water on Earth.

At the Millennium Summit held September 6-8 2000 at the UN headquarters in New York, the leaders of 147 countries signed the Millennium Declaration, which contains 8 global objectives, which should be achieved by the year 2015 (UN Resolution A/55/L.2). Millennium Development Goals relate to development and poverty eradication, including the "cut to half by 2015 number of people whose income is less than one dollar a day, the number of people who suffer from hunger and, by the same year, halve the number of people who have no access to or can not pay for safe drinking water" (UN, 2000). Johannesburg Declaration adopted at the World Summit on Sustainable Development held in 2002 (UN, 2002), enlarged the above target also to access to sewerage and provision of sanitary living conditions.

Global population growth and an increase in average water consumption are the main reasons for the low availability of drinking water in the world. Data for 2008 show that the total world population reached 6.6 billion people - UN report "The World at Six Billion" indicates that the world had a billion people in 1804, two billion in 1927, three in 1960, four in 1974, five in 1987 and six billion inhabitants in 1999, which was the basis for projection that in 2013, 2028 and 2054 the planet will have seven, eight and nine billion people (estimated by United Nations Population Division).

Viewing Earth as a whole, the total availability of water in the world is sufficient to cover all the needs of today's population. However, the problem is the uneven distribuiranost of water on the planet, as well as the temporal variation of water amounts available. On one hand, it happens that there is no water where it is needed, nor is there in sufficient quantities, on the other hand, there is too much in the wrong place and at wrong time.

Table 7.3 The coverage of water supply and sanitation services in different parts of the world

Continent	% water available	% population
North and Central America	15%	8%
South America	26%	6%
Europa	8%	13%
Africa	11%	13%
Asia	35%	59%
Australia and Oceanija	5%	1%

(Izvor: WWDR, 2003)

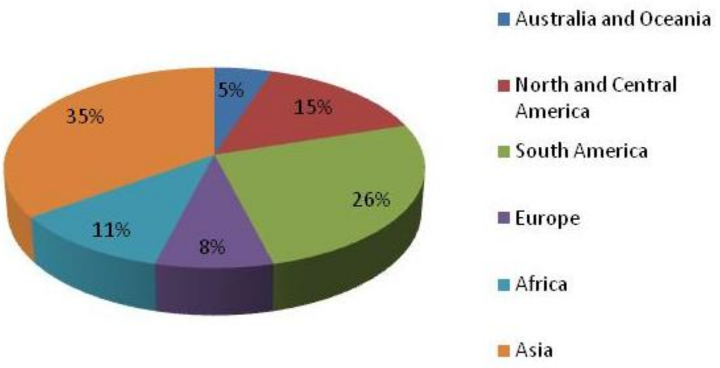

Figure 7.2 World water distribution

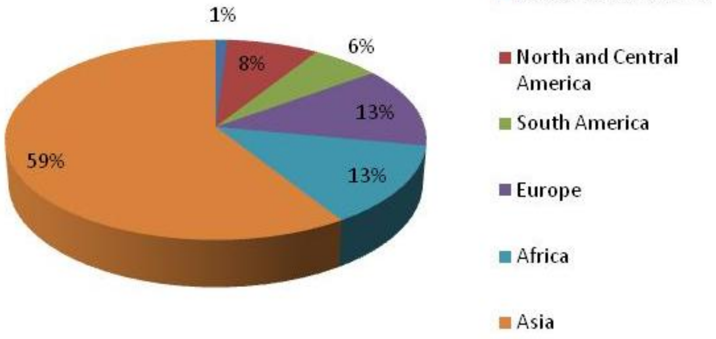

Figure 7.3 World population distribution

Two world regions - Africa and the Middle East - are already facing the serious water shortages, due both to rapid population growth in these areas, so as the fact that these regions have very scarce water reserves. When a country's water availability falls below 1700 m^3 per capita per year, it is considered that the country is facing "water stress". At the level between 1700 and 1,000 m^3 per person, one can expect periodic or limited water scarcity. If the annual average falls below 1000 m^3 per person, the state is facing serious water shortages[10].

Access to safe water is measured by the number or percentage of population that access enough water for drinking, hygiene and other household needs in an ac-

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[10] http://academic.evergreen.edu/g/grossmaz/larsenst/

ceptable and safe way. According to UN data from 2003 even 1.2 billion people have no safe access to clean drinking water, which is about 20% of the world's population. Safe access to water includes connections to public water supply, public taps or manhole with water, protected well or spring, so as rainwater collected in protected tanks. The main reason for the lack of secure access to clean water is the inability to maintain adequate funding and infrastructure for water supply. Large density of population and scarcity of water reserves in the world are also contributing to this state. Cities in some of poor countries, where water supplies are insufficient, e.g. in Mumbai or in Delhi (India), are facing a big contradiction: it is exactly the poorest part of population that does not have enough water and is forced to buy water from private vendors at much higher price than it would cost if coming from the water tap.

Table 7.4 Percentage of population by countries with access to safe drinking water[11]

REGION and STATE	% population with access to safe water (2002)	REGION and STATE	% population with access to safe water (2002)
AFRICA		SOUTH AMERICA	
Algeria	87	Bolivia	85
Burundi	79	Brasil	89
Cameroon	63	Chile	95
Central African Republic	75	Columbia	92
Chad	34	Ecuador	86
Congo	46	Venezuela	83
Egypt	98		
Ethiopia	22	ASIA	
Kenai	62	Afghanistan	13
Libya	72	Armenia	92
Mali	48	Cambodia	34
Morocco	80	Kina	77
Nigeria	60	India	86
Senegal	72	Indonesia	78
Somalia	29	Iran	93

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[11] http://www.worldwater.org/data.html

REGION and STATE	% population with access to safe water (2002)	REGION and STATE	% population with access to safe water (2002)
South Africa	87	Japan	100
Sudan	69	Malaysia	95
Tunis	82	Pakistan	90
Uganda	56	Thailand	85
Zambia	55	Turkey	93
Zimbabwe	83		
NORTH AND CENTRAL AMERICA AND CARIBBEAN		OCEANIA	
Bahamas	97	Australia	100
El Salvador	82		
Canada	100	EUROPE	
Cuba	91	Albania	97
Dominican Republic	93	Bosnia and Herzegovina	90
Haiti	71	Hungary	99
Jamaica	93	Netherlands	100
Nicaragua	81	Moldavia	92
Panama	91	Romania	57
USA	100	Russia	96
		Serbia	93
		Ukraine	98

There are significant differences when it comes to rural or urban population. Its rural population has about 20% less access to safe water than urban, and in some countries, particularly in Africa, the percentage of rural population that has access to safe drinking water is half of those in urban areas. Of the total population in the world who lack access to safe water, the highest rate is in Asia (65 %), then in Africa (27 %), Latin America (6 %) and Europe (2 %) (WWDR, 2003).

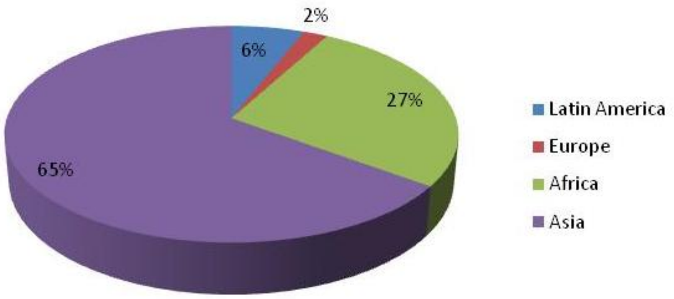

Figure 7.4 Percentage of population by continents who have no access to safe drinking water

7.2.2 Sanitary Conditions

Acceptable sanitary conditions include households' and companies' connection to the safe sewage system, that does not endanger human health. Poor sanitary conditions can cause water and the environment pollution, and pose a danger to human health.

As stated in the previous chapter, one of the goals set at the International Summit on Sustainable Development held in Johannesburg in 2002 is to reduce to half share of the world's population that does not have adequate sanitation by 2015.. According to UN data of 2003, 2.4 billion people did not have acceptable sanitary living conditions, what means that they did not have connection to a public sewer system, sanitary septic tank, toilet with sewer or septic tank equipped with a ventilation hole.

Table 7.5 Percentage of population by countries with access to adequate sanitation[12]

REGION and STATE	% population with access to appropr. sanit. (2002)	REGIJA I DRŽAVA	% population with access to appropr. sanit. (2002)
AFRICA		SOUTH AMERICA	
Algeria	92	Bolivia	45
Burundi	36	Brazil	75

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[12] http://www.worldwater.org/data.html

REGION and STATE	% population with access to appropr. sanit. (2002)	REGIJA I DRŽAVA	% population with access to appropr. sanit. (2002)
Cameroon	48	Chile	92
Central African Republic	27	Columbia	86
Chad	8	Ecuador	72
Congo	9	Venezuela	68
Egypt	68		
Ethiopia	6	ASIA	
Kenya	48	Afghanistan	8
Libya	97	Armenia	84
Mali	45	Cambodia	16
Morocco	61	Kina	44
Nigeria	38	India	30
Senegal	52	Indonesia	52
Somalia	25	Iran	84
South Africa	67	Japan	100
Sudan	34	Malaysia	95
Tunis	80	Pakistan	54
Uganda	41	Thailand	99
Zambia	45	Turkey	83
Zimbabwe	57		
		OCEANIA	
		Australia	100
NORTH and CENTRAL AMERICA and CARIBBEAN		EUROPE	
Bahamas	100	Albania	89
El Salvador	63	Bosnia and Herzegovina	68
Canada	100	Hungary	95
Cuba	98	Moldavia	68
Dominicans Republic	57	Romania	51
Haiti	34	Russia	87
Jamaica	80	Serbia	87
Panama	72	Ukraine	99

REGION and STATE	% population with access to appropr. sanit. (2002)	REGIJA I DRŽAVA	% population with access to appropr. sanit. (2002)
USA	100		

Differences in sanitary conditions between urban and rural population are still higher than is the case with access to water. Access to sanitation is twice lower in rural than in urban areas, and in some countries rural areas have almost no adequate sanitation.

Of the total world population that lacks access to adequate sanitary conditions, the highest rate in Asia (80 %), followed by Africa (13 %), Latin America (5 %) and Europe (2 %) (WHO/UNICEF, 2002).

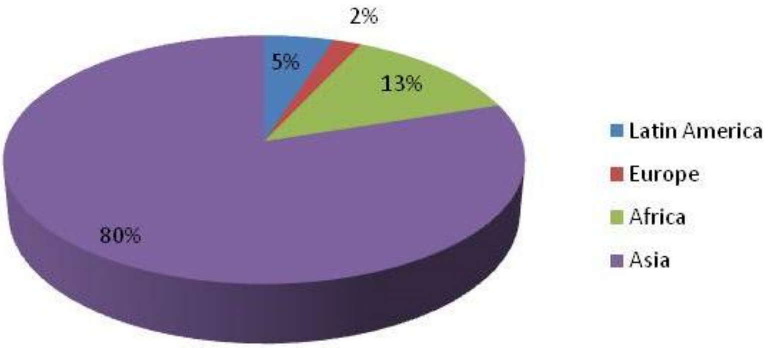

Figure 7.5 Percentage of population by continents without access to adequate sanitation

7.2.3 Lack of Access to Water and Public Health

Water is the basis for life and without water one can not survive for more than a few days. Water plays a vital role in the functioning of human body organs, it protects the immune system and helps in removing harmful substances from the body. In order to perform its function properly, water must be available and safe ("He who has health has hope, and who has hope has everything", Arabian proverb).

Lack of access to safe water and sanitation has a major impact on human health. Use of contaminated water can lead to various infectious diseases and diseases caused by toxic chemicals, and both of these types of diseases can be life-threatening. Rapid spread of infection can occur especially if there exists no adequate sanitary living conditions.

The most widespread infectious diseases caused by water and poor sanitary conditions include diarrhea, typhoid and cholera, which are leading causes of illness and death in developing countries, while bacteria such as Cryptosporidium, Campylobacter and E. coli occur also in industrialized countries around the world.

According to UN figures, every year over 3 million people die of illnesses caused by using contaminated and unclean water. Around 1.8 million children die each year of diseases caused by impure water and poor sanitary conditions, which means that on average even 5,000 children die every day for these reasons. The water caused diseases are the second largest killer of children worldwide, just after the acute respiratory tract infections such as tuberculosis.

Table 7.6 Diseases caused by unsafe water and poor sanitary conditions[13]

Disease	Cause and Route of Transmission	Geographic Extent	Number of Cases	Deaths Per Year
Amoebic dysentery	Protozoa travel the fecal-oral route via contaminated water, food, person-to-person contact.	Worldwide	500 million per year	Included in diarrheal disease
Bacillary dysentery	Bacteria travel the fecal-oral route via contaminated water, food, person-to-person contact.	Worldwide	Included in diarrheal disease	Included in diarrheal disease
Diarrheal disease (including amoebic and bacillary dysentery)	Various bacteria, viruses, and protozoa travel the fecal-oral route via contaminated water, food, person-to-person contact.	Worldwide	4 billion currently	3-4 million
Cholera	Bacteria travel the fecal-oral route via contaminated water, food, person-to-person contact.	South America, Africa, Asia	384,000 per year	20,000

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[13] http://www.infoforhealth.org/pr/m14/m14table.shtml#table2

Hepatitis A	Virus travels the fecal-oral route via contaminated water, food, person-to-person contact.	Worldwide	600,000 to 3 million per year	2,400 to 12,000
Paratyphoid and typhoid	Bacteria travel the fecal-oral route via contaminated water, food, person-to-person contact.	80% in Asia; 20% in Latin America, Africa	16 million currently	600,000
Polio	Virus travels the fecal-oral route via contaminated water, food, person-to-person contact.	66% in India; 34% in Near East, Asia, Africa	82,000 currently	9,000

Just diarrhea (including cholera), which is caused by polluted water, induces that about 2 million people die every year, out of which 90 % of children under 5 years of age, mostly in developing countries. 88% of the total number of cases of diarrhea were directly attributed to unsafe water sources and inadequate sanitation. According to the World Health Organization (WHO) research, mortality in diarrheal diseases can be reduced by 6-25 % if potable water supply conditions are improved, and by 32 % if the living sanitary conditions are improved. Personal hygiene, especially regular hand washing, can reduce diarrheal disease mortality by as much as 45% (WHO, 2004).

Table 7.6 shows the diseases caused by unclean or contaminated water, the way the disease spread, spread of diseases in the world, as well as the reported number of deaths (WHO, 2004).

7.2.4 Minimal Required Amount of Water and Actual Consumption

A number of studies tried to assess the daily amount of water required to maintain minimum living conditions, and different researches have led to mixed results - mostly states that a man should need daily between 20 and 50 liters of potable water to carry out own daily activities (for cooking, washing, etc.). In addition, in order that the water would be considered as available it must be located a reasonable distance, or up to 200 m from the front door.

The amount of water that people on average actually use varies from state to state, and depends not only on the availability of water for human needs, but also on the economic development and degree of urbanization. Out of the three standard categories of water consumers - households, industry and agriculture, the highest amount of water is used in agriculture. At the global level, agriculture consumes 69 % of the total annual amount of water consumed, industry 23 % and households around 8 %. Each person is required about 2,800 calories a day, and to to produce the amount of food required for that one needs about 1,000 m^3 of water per year, or nearly 2800 liters per day, which is the reason why agriculture is the largest water consumer in the world. For example, to produce just one kg of beef one needs as many as 15,000 liters of water, producing two pounds of lamb needs 10.000 l, and for one kg of grain one will spend 1,500 l of water, etc.

If the average water consumption is estimated by the continents, the distribution differs a lot. Water consumption in the individual country is heavily dependent on the economic development. In developing countries people can use much less water per day than in developed countries. For example, in Africa the average annual water consumption per capita is only 17 m^3 (or 47 liters a day), in Asia 31 m^3 (or 85 liters a day), in Great Britain 122 m^3 (or 334 liters per day), while in the U.S. it is 211 m^3, or 578 liters per day (Hinrichsen et al, 1998). The average person in Europe consumes about 200 liters of water per day, in North America about 400 liters, while in some developing countries the average person consumes only about 10 liters of water daily for drinking, washing and cooking. Probably the most stirking data about the uneven availability of drinking water for humans is the one that says that a child born in the developed countries spends between thirty and fifty times more water than a child born in very poor countries. The following table shows the devastating information about water availability in the poorest developing countries - as opposed to these data are figures of 500 l of water per day spent by an average U.S. resident, or 200 l by resident of Great Britain (Russell and Morris, 2006).

Table 7.7 Water consumption per capita in the poorest developing countries

State	Daily water consumption liters per capita
Gambia	4,5
Mali	8,0
Somalia	8,9
Mozambique	9,3
Uganda	9,3
Cambodia	9,5
Tanzania	10,1

8

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9

Lists

9.1 Abbreviations

BiH	Bosna i Hercegovina
EBI	Extended Biotic Index
EU	European Union
GWP	Global Water Partnership
IWRM	Integrated Water Resources Management
NGO	Non-Governmental Organization
RBD	River Basin District
RBMP	River Basin Management Plan
TARWR	Total Actual Renewable Water Resources
UN ECE	United Nations Economic Commission for Europe
UN	United Nations
UNICEF	United Nations Children's Fund
WFD	Water Framework Directive
WHO	World Health Organization
WWF	World Wide Fund for Nature

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