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V. N. Karazin Kharkiv national university

«Library of ecologist»

ENVIRONMENT MANAGEMENT ACTIVITY

TEXTBOOK

Under the editorship of N. V. Maksymenko

Kharkiv – 2012

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Textbook «Environment management activity » contains selected lectures in Ukrainian and English languages which allow to learn more efficiently the course of Environment management activity being a normative subject of professional preparation at the level «bachelor» and «magistr». The textbook contains a bulk of materials concerning international aspects of ecological activity management based on international normtive legal documents. A textbook, except for a student audience, can be useful to any specialist working in the field of ecology.

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Міністерство освіти і науки, молоді та спорту України
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Харківський національний університет імені В. Н. Каразіна

«Бібліотека еколога»

УПРАВЛІННЯ ЕКОЛОГІЧНОЮ ДІЯЛЬНІСТЮ

Навчальний посібник для студентів
вищих навчальних закладів

За загальною редакцією Максименко Н. В.

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Навчальний посібник «Управління екологічною діяльністю» містить вибіркові лекції українською і англійською мовами, що дозволять краще засвоїти курс «Організація управління в екологічній діяльності», який належить до нормативних дисциплін фахової підготовки рівня «бакалавр» та курсу «Екологічний менеджмент» фахової підготовки рівня «магістр». Посібник містить великий обсяг матеріалів щодо міжнародних аспектів управління екологічною діяльністю, що ґрунтується на міжнародних нормативно-правових документах.

Посібник, крім студентської аудиторії, може бути корисним для будь-якого спеціаліста, що працює в сфері екології.

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ЗМІСТ

CONTENTS

ВСТУП

Сучасні реалії міжнародних відносин дуже красномовно доводять, що без об'єднання спільних зусиль по збереженню якомога кращого навколишнього середовища перспектива гармонійного розвитку нашого суспільства залишиться лише нездійсненною мрією. Розвиток технічних засобів, що дозволяють «скоротити» відстані між людьми і країнами допомагає адекватно оцінити роль міжнародної спільноти у запобіганні екологічній кризі. На порядку денному зараз постає питання узгодження екологічно спрямованої діяльності в різних країнах як на рівні керівництва, так і на рівні простих громадян.

Для вирішення цієї проблеми, у першу чергу, необхідно усвідомити реальну спільну екологічну мету людства, яка не залежить від рівня економічного і соціального розвитку країн – це, говорячи пафосно, збереження життя на планеті Земля. Кожен крок техногенних перетворень має бути заздалегідь чітко вивірений з його екологічними наслідками і, у зв'язку з цим, визначена його не лише економічна, а й екологічна доцільність.

Весь час існування людства на нашій планеті пов'язане з переважно негативним впливом на довкілля, але цей процес не може бути нескінченним. Саме тому на порозі XXI сторіччя міжнародна спільнота здійснила кроки, спрямовані на обмеження, скорочення і оптимізацію ступеню антропогенного навантаження на навколишнє середовище. За ініціативи Організації Об'єднаних Націй, міжурядових і неурядових організацій відбулось ряд самітів, результатом яких стало підписання міжнародних угод екологічного спрямування. Країни, що ратифікували ці угоди взяли на себе зобов'язання по обмеженню впливу на довкілля і, таким чином, відкрили собі шлях до екологічно безпечного майбутнього. Надалі в цих країнах вся економічна діяльність має узгоджуватись з екологічно доцільними рекомендаціями міжнародної спільноти у відповідних галузях.

Підготовка фахівця-еколога обов'язково потребує знання як міжнародних екологічних угод, так і шляхів їх реалізації у конкретних країнах і на конкретних напрямах. Для задоволення цієї потреби у межах проекту Темпус «Удосконалення освіти в галузі екологічного менеджменту» створено даний навчальний посібник, над яким працював міжнародний колектив вчених, що представляють Україну, Білорусь, Угорщину, Німеччину і Грецію. Автори, прізвища яких вказані у змісті поруч із назвою розділів, що ними підготовлені, намагались показати сучасний стан управління екологічною діяльністю в конкретних країнах, конкретних регіонах, окреслити проблеми, що існують там, а також окреслити перспективи, що відкриває міжнародне співробітництво в екології.

Навчальний посібник структурований за трьома модулями, в кожному з яких наведено тексти лекцій українською чи англійською мовами зі списком рекомендованої для вивчення літератури. Після лекції надано перелік контрольних питань англійською і українською мовами для перевірки знань студентів, практичні завдання і запитання для тестового контролю знань.

INTRODUCTION

Modern realities of international relations eloquently argue that without joint efforts to maintain the best possible environment the prospect of harmonious development of our society will remain just an unrealized dream. Development of technical tools to "shorten" the distance between people and countries helps to adequately assess the role of the international community in prevention of environmental crisis. On the agenda is the question of coordination of ecologically oriented activities in different countries at the level of leadership, and the level of ordinary citizens.

To resolve this problem, first of all, it is necessary to understand the real common environmental goal of humanity, regardless of the level of economic and social development – that is, to preserve life on the planet Earth. Every step of technological change must be clearly verified before its environmental consequences set up and, therefore, not only its economic but also environmental feasibility should be determined.

The entire time of mankind's existence on our planet is concerned mainly with negative impact on the environment, but this process can not be infinite. Therefore, on the threshold of XXI century the international community has taken steps to limit, reduce and optimize the degree of anthropogenic pressure on the environment. Initiated by the United Nations, intergovernmental and non-governmental organizations have held a series of summits which have led to the signing of international ecological agreements. The countries that have ratified these agreements have made commitments to limit the environmental impact and thus opened a way for an environmentally secure future. In future all economic activities in these countries should be consistent with ecologically appropriate recommendations of the international community in their respective industries.

Training of expert ecologists requires knowledge of both international environmental agreements, and ways of their implementation in specific countries and specific areas. To meet these requirements a new textbook has been created within the Tempus project "Improvement of Education in Environmental

Management"; an international team of scientists, representing Ukraine, Belarus, Hungary, Germany and Greece have been working on its creation. The authors, whose names are listed in the table of contents next to the chapters that they prepared, tried to show the current state of environmental activities in specific countries, specific regions, to outline the problems that exist there, and also identify the prospects that open international cooperation in ecology.

The textbook is structured in three modules, each of which contains texts of lectures in Ukrainian or English with a list of recommended literature for the study. After each lecture there is a checklist of comprehension questions and practical tasks in English and Ukrainian languages to test students' knowledge.

Модуль 1.

ЗАГАЛЬНІ ПИТАННЯ ЕКОЛОГІЧНОГО УПРАВЛІННЯ КОМПОНЕНТАМИ ДОВКІЛЛЯ

1.1. WATER RESOURCES MANAGEMENT

Water is an essential resource for life and water resources management (WRM) is a significant element of a wider environmental management field. The major goal of a water resources management is to provide an adequate response to the key factors, affecting water resources, such as – enhanced water consumption due to population growth, especially in water-scarce regions – urbanization processes, leading to higher concentration of water consumers in one place – enhancement of living standards, leading to higher water consumption – pollution from industrial processes, residential consumers and agriculture.

Coordinated development and management of water and related resources with minimization of impact on environmental sustainability and ecosystems and, at the same time, achieving the best resultant economic and social welfare is a foundation of successful development of a society as a whole.

The next chapters provide a brief overview of the state of the Earth's water resources, introduce the concept of a water-economy complex (WEC), and explain the structure of modern water consumption, elaborate on the water needs, demands and users across the branches of the economy. Further on, a strategy for water resources management is presented. In particular, approaches and strategies for water resources management in the context of sustainable development are offered, the concept of systems analysis of water resources management and water-economy complex management is introduced. Mathematical modeling of a water-economy complex and its practical applications are discussed.

Presented material will help to build the knowledge base and develop competencies, necessary for the future water resources managers. Comprehension tasks and assignments, available at the end of the chapters, help to do a self-check on the key points, presented in a text.

1.1.1. WATER, HYDROSPHERE AND WATER RESOURCES OF THE EARTH

1.1.1.1. Water and the WR as the base of life on the Earth

Without water life on the Earth would be impossible. Water content amounts to 50-90 % of weight of all plants and animals. In human body content of water is about 70 %.

Water is a chemical composition of oxygen (88.89 %) and hydrogen (11.11 % by weight). Water vapour (hydrol) formula H_2O is the simplest, while ice is a combination of three simple molecules $(H_2O)_3$ (trihydrol).

Total amount of water on the planet by various evaluations is within 1.5 to 2.5 billion km^3. Per one hectare of the land it would correspond to 30-50 billion t. of water. Approximate distribution of water on the Earth is given in Table 1.1.

Table 1.1

Volume of water on the Earth

Water site	***Volume, billion km^3***
World oceans	1370.0
Groundwater	60.0
Glaciers	35.3
Lakes and rivers	0.5
Soil moisture	<0.085
Atmosphere	0.014
Total	**1454.679**

All kinds of human activities in some way are connected with water.

Water possesses extremely unique physical properties. It is the only liquid mass in nature with such unique properties. Dr. Loren Eisley has coined the following aphorism: «If there is magic on this planet, it is in water».

Water can exist in three physical states: solid (ice) at temperature below 0 ^{0}C (temperature of ice freezing/melting), liquid at temperature from 0 ^{0}C and <100 ^{0}C under normal atmospheric pressure, and as water vapour at temperature >100 ^{0}C. The existence of water on the planet in all three states is of exceptional importance.

If the temperatures of water evaporation and freezing were different, then our planet would had been either in ice carapace or enveloped in water vapour atmosphere at temperatures precluding existence of earthly forms of life, due to the amount of solar energy continuously flowing to the Earth.

Water has great specific evaporation heat. And this property allows transferring solar heat with water vapors from seas and ocean's surface to the land. In this way there is continuous heat exchange between ocean and land, determining the planet climate.

Water capacity for heat accumulation and delivery is the main factor in solar energy redistribution on the surface of our planet.

Water has high heat capacity. Elevation of temperature by 1^{0}C leads to accumulation in 1 g of water 4200 J of heat energy. When cooling, water delivers the same amount of heat. As a result, in summer months seas and oceans are accumulating huge amounts of energy, delivering it during cold seasons of the year. The processes of heat accumulation and delivery are going on slowly, without sharp falls in temperature. And it is very important for climate formation. Water is widely used for cooling purposes in industry.

The unique property of water to expand on freezing is extremely important for formation of suitable conditions of life on earth. Ice density is less than that of water. In cold seasons water bodies are covered with ice which is a good thermo-insulator, retarding further cooling of the water body.

Water is excellent dissolving agent for many chemical compounds and substances. This is favorable for dissolution and transfer of nutrients for animals and plants. At the same time water removes dissolvable wastes of vital activity. Such processes are going on in natural environment and within living organisms.

Water is also a universal purifier. Biological wastes removed to water bodies under influence of self-purification processes going on in the water body are being decomposed and mineralized. But this occurs only if the water body is not overloaded with wastes to such extent which can cause its degradation.

Trees and agricultural crops and all plants are living and developing due to water property to dissolve and transfer nutrients from soils. Here the property of capillary rise of water in the soil pores is very important. The pore water due to surface tension and soil particles wetting can rise up to 0.5-0.6 m. At that dissolved nutrients are transferred to the plant roots. Capillary transfer of saps is also going on from roots upward.

We can only marvel at Creator's wisdom, at wisdom of the Mother Nature who bestowed on humanity such magic substance as water.

It is thus no wonder that WR are of such importance for development and future existence of our civilization.

1.1.1.2. Hydrosphere of the Earth

Nowadays it is widely accepted when considering global problems of human development and natural environment to investigate biosphere (Biosphere is the region of the Earth and its atmosphere, all hydrosphere, and upper part of lithosphere in which life exists) in which hydrosphere is its component.

The Earth hydrosphere is a discontinuous water layer consisting of oceans, seas, rivers, swamps, glaciers and groundwater.

In contrast to continuous World Ocean, hydrosphere is discontinuous because the water bodies – rivers, lakes, rocks, aquifers (Aquifer – an underground water-bearing layer of porous rock) are discrete and intermittent with waterless part of lithosphere.

Hydrosphere is highly dynamic, with continuous movement of waters caused by hydrologic cycle.

Groundwater is connected with surface waters of seas, rivers, and lakes. Groundwater is recharged with surface waters infiltrating into aquifers. In its turn, groundwater is alimentating rivers, lakes and seas in the zones of active water exchange. Groundwater outflows to the land surface as springs and rivulets, which often are forming river heads. So groundwater may be considered as an integral part of the earth surface waters.

Water contained as vapors in the atmosphere also is an integral part of the hydrosphere. Vapors are formed by evaporation from the ocean surface and from land waters. Vapors transformed into rain drops, snow, or hail is precipitating on the land and ocean.

In addition to free water in lithosphere and living organisms there is also physically and chemically connected water in minerals and organic compounds. Free water is subjected to influence of gravitational forces and can be transformed to various aggregate states (ice ↔ vapour ↔ water ↔ ice ↔ vapour) under action of fluxes of thermal energy and/or processes of diffusion.

Hydrosphere is closely connected with atmosphere, lithosphere and living organisms in biosphere, i.e. it is an integral part of the earth's biosphere. With lithosphere hydrosphere is connected through groundwater, while with atmosphere through continuous interchange of atmospheric water. Living organisms are connected with hydrosphere first of all by considerable content of water in their biomass. Water is connected with biological processes since incipience of life J.Bernal states that «Life in essence is a derivative of water».

Generation of the organic substance in the process of photosynthesis with participation of water is yet another it's extremely important function. So, water is an obligatory component in creation of the basis for the animal and vegetative universe and for soil formation. Water also participates in the process of transpiration in plants.

Groundwater is involved to the hydrologic cycle in various degrees: from stagnant zones of the age corresponding to that of the enclosing rocks, to a seasonal groundwater formed during wet periods and disappearing in dry ones.

Atmospheric vapors also pertain to hydrosphere. Humidity is present within troposphere, i.e. up to 16-18 km high in the equatorial zone and up to 10-12 km in middle latitudes. In polar areas it is 7-10 km high. Vapour volume recalculated as water, amounts to about 14 000 km^3. Though this volume is small, its importance is very high because it gives the outset to all sweet waters of the earth. This relatively small and stable component of hydrosphere is generating as a result of reiterative hydrological cycles almost 40-fold volume of atmospheric precipitations forming fresh waters of the earth.

Fresh waters as the hydrosphere component are representing the main part of the WR of the earth, necessary for humanity. Fresh water reserves are of special interest because they provide for the main needs of human society.

Fresh waters amount to about 2.5 % of the total volume of hydrosphere, i.e. about 45 billion km^3. About half of it is “stored” in huge ice caps of Antarctic, Arctic, Greenland, and high mountains in various parts of the earth.

The volume of available fresh water now amounts to thousands of cubic km, but not to millions. Lakes contain the greatest volume of surface fresh water: 176.4 billion km^3.

Origins of multitude of rivers are in swamps containing 10.3 billion km^3. If the flowing of all rivers on the earth were stopped for a moment, then the total amount of water in their beds would be 2.12 billion km^3. In the near-surface layers of atmosphere there are 13 000 t of water. At the height up to 1 km concentration of water vapors in the air on the average is equal to 2 %.

Volume of man-made large reservoirs in the whole world amounts to 5 billion km^3. That’s practically all water available to humanity at present and in the near future.

Summing up, it can be stated that in the Earth hydrosphere fresh water is amounting to a small part. Of the total volume about 50 % is stored in polar glaciers as ice and at present is practically unavailable for use. The offered figures confirm limitation of WR available to humanity. But such general figures do not reflect the situation with real resources of fresh water. For objective evaluation it is necessary to take into account dynamic processes going on in hydrosphere and continuously renewing steady volume of fresh water. The hydrologic cycle is a moving force renewing fresh WR.

1.1.1.3. Water resources balance

It is clear that the availability of WR – with allowance for their quality and accessibility is among most important indices of the natural potential of territory (country, continent, etc).

As it has been indicated, amount of water on the earth is limited. It is especially true for fresh waters which are most intensively used by man.

Accounting for and planning of use of WR is performed with the help of a hydrologic budget computations. When planning use of water it is necessary to take into account the fact that any use of one source of water is inevitably impacting all other water sources. For example, retention of water on agricultural lands for crop augmentation is leading to depletion of the river flow. Intensive abstraction of groundwater may reduce ground alimentation of rivers, and so on.

Water balance reflects relationship between quantity of water oncoming to the globe surface as precipitations and volume of evaporations from the land and the ocean for a certain period of time. Precipitations, evaporation and river flows are the main components of the water balance.

The river flow consists of two genetically different parts: of surface flow, creating floods and groundwater drained by rivers. Rivers with surface alimentation, existing in many regions, are having unsteady flow. Groundwater alimentation of rivers is providing steady source of fresh water so necessary for humanity.

In addition to the main components of the water balance (i.e. precipitations, evaporation, and river flow) there are also other components. Soil moisture is an element of the water balance. It is also one of the most important elements of the soil fertility.

Soil is the medium where the most important hydrological processes are going on: infiltration of water to deep layers and generation of surface runoff. So, soil is an intermediate between the river and meteorological events. It also interconnects groundwater with surface sources, and therefore it is the most important factor of the water balance of a territory.

The main components of the earth water balance are given in Table 1.2.

It is important to remember that human activities are strongly acting practically on all main components of nature. And the water balance and river flow are strongly affected by man. For computation and complex analysis of the water balance components, including river flow and its components, it is necessary to apply mathematical models. And this demands comprehensive theoretical and experimental investigations of these processes.

Table 1.2

Mean annual water balance of the Earth

Surface	*Area, billion km²*	*Volume, km³*		
		Evaporation	*Precipitations*	*Flow*
Globe	510	577 000	577 000	-
World Ocean	361	505 000	458 000	47 000
Land	149	72 000	11 900	47 000
including: area with flow to ocean	119	63 000	110 000	47 000
area with seepage flow	30	9 00	9 000	-

1.1.1.4. Renewable water resources of Earth

In the process of WR study a special attention is paid to the fresh water balance, as the most significant component of the WR.

Renewable WR are of special importance for humanity. The amount of such resources is comparable with the river flow. The latest data indicate that the volume of renewable WR for the years 1921 to 1985 has been 42700 km^3/yr (without Antarctic). In the 90-s of the XX century the potential provision of population with water on average amounted to 7600 m^3 per year per capita, with fluctuation for continents: for Asia 3400 m^3, for South America 38000 m^3, and for Australia and Oceania 84000 m^3.

Results of investigation of the river flow volume elucidated existence of multiannual cyclic fluctuations in the total world and separate continents volumes. And at the same time it is symptomatic of the river flow that there is no clear trend for the last 70 years in its fluctuations. Augmentation of the South America river flow for the last twenty years went concurrently with decrease in African rivers flow.

In predominant number of rivers annual flow is distributed very unevenly. Its main part (60-70%) is formed during freshet periods. According to modern data in Europe during April-July passes 46% of annual flow, in Asia in June-September 54%, in Africa in September-December 46%, in the North America in May-August 49%, in South America in April-June 45%, in Australia and Oceania in January-April 46%. On the land as a whole wet season is going on from May till August. In this period the globe rivers flow in total amounts to about 45 % of the annual flow.

It has been established that amount of WR in various regions of the Earth is determined mainly by climatic factors.

Interannual fluctuation in regional WR can be very considerable, and for continents they deviate from average values to a great degree. It is especially true for arid and semiarid regions where amount of WR is low.

The greatest river of the world the Amazon gives 16 % the annual flow of the rivers of the world. And water of the five largest rivers of the world (the Amazon, the Ganges with the Brahmaputra, the Kongo, the Yangtse, the Orinoco) represent about 27 % of the world fresh WR.

About half of the total river water discharge to the World Ocean is going on to the Atlantic, receiving flows of four largest rivers of the world (the Amazon, the Kongo, the Orinoco, and the Parana). The Arctic Ocean receives only 4300 km^3/yr of river waters, but for the ocean regime these waters are especially important. This is due to the fact that in the Arctic Ocean there is only 1.2 % of the total volume of water of the World Ocean, and it receives about 11 % of the world rivers flow. Analysis of available data indicates that the total inflow of water in the World Ocean is rather stable, without any clear trend to fluctuation.

At the same time, for the considered period there is a noticeable tendency for decrease in inflow to the Indian and the Pacific Oceans, and its augmentation to the Atlantic.

Reliable evaluation of renewable WR of separate countries is of the main practical interest. Available data indicate to a very uneven distribution of WR and their availability in separate countries of the world.

The values of specific water availability are fluctuating in wide limits: from 0.400 – 5000 m^3 up to 1000’000 – 1’800’000 m^3 per year per 1 km^2 of area, and from 0.180 – 1500 m^3 to 100’000 – 500’000 m^3/yr per capita.

A degree of fresh water use is usually determined by coefficient, K_w, equal to ratio of volumes of water use and renewable WR. By K_w magnitudes all regions and countries are separated into four categories:

- 1-st category K_w = 10 % – low load on WR;
- 2-nd category K_w = 10-20 % – intermediate load:

- 3-rd category K_w = 20-40 % – high load;
- 4-th category K_w > 40 % – very high load on WR.

On the basis of this classification it can be stated that in the year 1950 the world situation with WR was fairly satisfactory. There were no regions in the world with very high load on WR. Only three regions (the North Africa, Central Asia, and Kazakhstan) could be referred to the third category (K_w = 20-40 %). All other regions were in categories of either low or intermediate loads on WR.

But nowadays situation changes drastically. In some regions of the world where lives over 70 % of the Earth's population there is high or very high load on WR. By the year 2025 the situation will deteriorate even more, and especially in developing countries on all continents. It can be expected that by that time over 80 % of the Earth's population will be living under conditions of high and very high loads on WR. At that about 30 % of the population would have load on WR equal to K_w > 60 % which can be considered as catastrophically high.

1.1.1.5. Water resources in the future

Problems of WR rational use and pollution prevention are very involved. On the global scale the number of relevant problems is enormous. And these problems are augmented by historical factors, because separate ways and methods of WR use and protection were evolving for a long period of time (some of them for centuries). But performed analyses demonstrated that some traditional trends have become obsolete and should be replaced with modern ones, corresponding to the present-day level of culture and technology.

On the one hand it is quite justifiably stated that the Earth is rich in fresh WR, and that they would eternally serve humanity, providing for all its needs. But on the other hand more and more often fears are expressed as to the threat of the WR depletion leading to limitation of the population growth. Such fears are based on the critical or nearing critical situation with WR in some regions of the world.

In later years started to appear unsubstantiated too optimistic points of view as to WR. Such optimist state that as water goes from cycle to cycle as use – purification – reuse, and so on, its resources are inexhaustible. It is true to a certain extent for the Earth as a whole. It is true that in water cycle the use of water is an inseparable component. But it doesn't mean that the use of water in its cycle provide for absence of unrestorable losses of water for population in a given area of the Earth.

The matter is that the convenience of water use depends upon its aggregate state and its place in the water cycle. And the link of the water cycle is also of importance. For example, the river link provides for more convenient sources of water supply for various types of water use than, say, oceanic link. Sometimes types of water use demand its transfer to a different link of the water cycle, even in contradiction to the natural processes of the cycle. So, e.g. river water abstracted for irrigation is mainly used for evaporation and transpiration. It means that water from the river link of the water cycle is transferred to the soil link and then to the atmospheric link, while a part of water is returned to the river (the return water).

But, as a result of such transfer from link to link certain losses of WR occur. Even if all evaporated water would be condensated and precipitated within the basin of the same river, the volume of water in the river would not be fully restored.

The volume of polluted river water is much greater than the volume of effluents discharged to the river. And this fact created the main threat to quality of WR. Even when river water is abstracted for water supply – and in some industries out of 100 units of water only 50 to 10 units are used for non-returnable purposes – the rest 90-95 units are returned to the river, but in a much deteriorated state. Restoration of WR is going on in the process of the water cycle, but their quantity is reduced as a result of water usage. Under natural conditions, without commercial water use, volumes of restored WR would be greater.

Often modern approaches to solution of the WR problem are one-sided. In some projects treatment of waste waters is considered as a panacea. In others they are enthusiastic as to sea water desalination. Yet others are for changes in technology, reducing water use or even leading to completely waterless processes. And there are proposals to transport water from one regions to others, e.g. transportation of icebergs from Arctic, etc. But none of these approaches is self-sufficient for solution of all problems of water, which are very complicated. They can be solved only by a complex approach, concurrent application of many measures. It is true for our time, and even more so for the future.

When planning complex approach it is important to remember that all components of hydrosphere and water sources are interconnected very closely in the magnificent process of the water cycle. It is also necessary to pay very close attention to all other components of nature. Only under such conditions a plan or project of WR protection can be considered as a complex one.

It is easy to provide all branches of economy with water where its quantity is sufficient. But under shortage of water branches of industry should be prioritized. Otherwise WR could be used for less important purposes, and the primary needs would remain unsatisfied.

Complex solution of the water economy problems should include questions of expedient siting of industries. At that the cost of water should never oppress industries. Sometimes it is economically more reasonable to transport raw materials and manufactured articles than to transport water.

Water use processes are subdividable in two categories: with and without abstraction of water from its source. For example, water supply and irrigation cannot be performed without water abstraction from its source. On the other hand, these processes generate large amounts of return waters, delivered to water sources. It means that the boundary between abstraction and non-abstraction usage of water sometimes is not very sharp.

Agriculture is a very large user of water. With augmentation of crops goes on augmentation in transpiration processes which are going on inconspicuously. And, as a result, they are not taken into account by the modern water engineering. But it is important factor and it should be taken into account, which can be fairly easily performed as there are methods for determination of transpiration rates.

The rate of recreational load on lakes and reservoirs is increasing from year to year, and it as well should be taken into account.

It is necessary to include into processes of WR use a component of their protection. And this would allow considering water protection like an integral part of its use, in contrast to the present situation when protection is considered as a superstructure, contradicting sometimes to aims of water use.

At the same time there is no doubt that it is necessary to have some rules and laws of WR protection in addition to integral methods of protection. It should start from promotion of a moral code for relationship of man with nature, including water. And such moral education should be initiated from the earliest age of children, in nursery and elementary schools.

Analysis of specific water supply quantities for all parts of the world and for separate countries for the years 1950-2025 has demonstrated very great non-uniformity of WR distribution. In the year 1995 the most rich in water were Canada, Alaska and Oceania. But in densely populated regions of Asia, Central and South Europe, Africa and Arabian peninsula it amounts only to 200-300 m^3/yr per capita. It should be remembered that volume of water less than 2000 m^3/yr per capita is considered as very small, and less than 1000 m^3/yr per capita as catastrophically low.

At present in the world 76 % of population is provided with less than 5000 m^3/yr per capita. At that 35 % are living with catastrophically low amounts of water.

And in XXI century situation will deteriorate. By the year 2025 majority of the world population would be living under conditions of very low and even catastrophically low quantity of available water.

For industrially developed countries the reduction of level of specific water availability would be relatively small. And it would be independent of climatic conditions and volumes of WR. For the period since the year 1950 till 2025 it would decrease in 1.8 times, while in water-rich developing countries such decrease would be on average in 4.5 times, and for water-poor countries 8.5 times. Such figures indicate to necessity of urgent measures aimed at prevention of slipping down to large-scale catastrophic situation.

1.1.1.6. Water component of the environment

The water component has some specific features as against other components of the natural environment. For elucidation of these features it is necessary first of all to agree upon what should be considered as the water component of the environment. As constituting parts of this component should be considered first of all potable water, and water used for food industry, municipal services, hygienic and balneological purposes; for agriculture, animal farming; and for provision of necessary regimes in water bodies – rivers, lakes, groundwater sources, etc. The state of water component is connected with anthropogenic use of water.

As to processes going on in the water component it is necessary to indicate first of all to river overflowing and land flooding, soil under flooding, logging, and processes of agricultural reclamation.

Water reservoirs are of high importance for extension of WR, augmentation of the steady river flow through reduction of floods, etc. Reservoirs are also very important for smoothing out seasonal and sometimes annual surging of water. Forestry and agriculture are strongly impacting biosphere as a whole and water component in particular. Highly productive forests (i.e. with mushrooms and berries) provide very strong water-protective actions. Forest soils have very favorable hydrological properties. Their high infiltration capacity minimizes non-point discharge and maximizes inflow to groundwater. In river basins with such forest rivers freshets are low, and groundwater discharge during dry periods is higher than in non-forested river basins.

Hydrological role of forest can be augmented by small-scale cuttings, with allowance for local reliefs, and by some other measures.

Drying of bogs and wetlands also strongly impacts the water component.

At least 30 % of the world population is living in towns and cities, strongly affecting natural environment, including water component. This problem so far is scanty studied. But already some conclusions can be drawn. Towns and industrial complexes are occupying considerable territories. In some small European countries built-up areas occupy up to 10 % of their territories. At such areas infiltration to groundwater is practically absent while the non-point discharge is much stronger. It has been established that municipal non-point discharges are polluted to a higher degree than sewage waters. And it is true for cities with good street cleaning and waste removing services.

Street watering improves sanitary state of municipalities. But at the same time these waters are polluting water bodies. This problem as yet is not solved. It seems it would be reasonable to separate municipal non-point discharges by degrees of their pollution. The most polluted portion should be directed to treatment units. Such method is applicable to storm waters. The problem with melt waters is more involved, and especially so in some northern cities and towns.

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1.1.2. MODERN WATER-ECONOMY COMPLEX, WATER SUPPLY, WATER CONSUMPTION, WATER USAGE

1.1.2.1. The water-economy complex as a whole

Natural water bodies are components of water resources usable by man for social, industrial and agricultural activities. And first of all it is necessary to provide for accumulation of necessary volumes of water, then to abstract water from water body, treat water, transport and distribute water among users, collect waste water and treat it and discharge of treated waste water with obligatory condition of water resources protection and prevention of natural water sources depletion.

The water-economy complex consists of municipal, industrial and agricultural water using and treatment units; together units for financial and technical servicing purposes.

As a result, water-economy problems can be solved by systemic approach with application of economic and mathematical methods of analysis. The WEC should provide for a maximum economic efficiency for the human society as a whole, as against benefits for separate enterprises of branches of industry. It should provide for minimal attainable negative impact of the environment, while providing for a guaranteed minimal water supply under emergency situations.

The WEC is an essential and inseparable component of the social and economic structure of the state as a whole and its regional units.In a case of situation of social, municipal, industrial, and agricultural units within a single river water-collection area they say about the river-basin WEC. Such basin approach provides for important advantages in the water resources management.

Provision of the necessary amounts of water for population, economics, and all other needs is an obligatory condition for successful steady development and security insurance of the state. Water resources (are a component of the natural wealth of the country, and their sparing use is a primary problem of the state administration.

The WEC consists of a number of subsystems providing for necessary water supply. Among them there are:

- water supply systems (municipal, industrial, agricultural), including reservoirs, water intakes, water processing and transportation systems;
- water removal (including waste waters processing and disinfection);
- hydrotechnology (irrigation and drainage systems; flood protection, water erosion, earth flows, creeps and bank destruction prevention, as well as soil bogging and salinization);
- hydroenergetics (hydroelectric power stations, hydroaccumulating stations);
- water transport, including tending for internal aquatic transport ways, and timber floating;
- fish husbandry;
- health protection and aquatic recreations.

The WEC consists of three interconnected parts: the natural, the technical, and the economic (Fig. 1.1).

The natural part includes water resources, geographic and climatic conditions. The technical part includes engineering units and means for their exploitation aimed at abstraction, transportation, use and removal of water, and also at water protection.

The economic part is dealing with attainment of a maximum economic effect of the WEC functioning, with concurrent minimization of damage to water resources. It also deals with efficient use of investments into the complex. The state WEC should be managed on the whole state level, so as to solve water problems on the basis of long-term forecasts of the state economic development, with allowance for social and political conditions.

The state WEC may be presented as a group of subcomplexes formed in separate parts of the country or at separate water-collection basins. In the process of the country development there are formed urbanized and industrialized regions on the basis of prevailing natural, geographic, economic, demographic and social conditions.

The regional WEC of the river basin is based upon use of the available water resources within the region. The technical part of the complex should provide for provision of necessary volume and quality of water at points of its abstraction and use. All water-engineering units should be provided with water-protective structures minimizing negative impacts of units' exploitation.

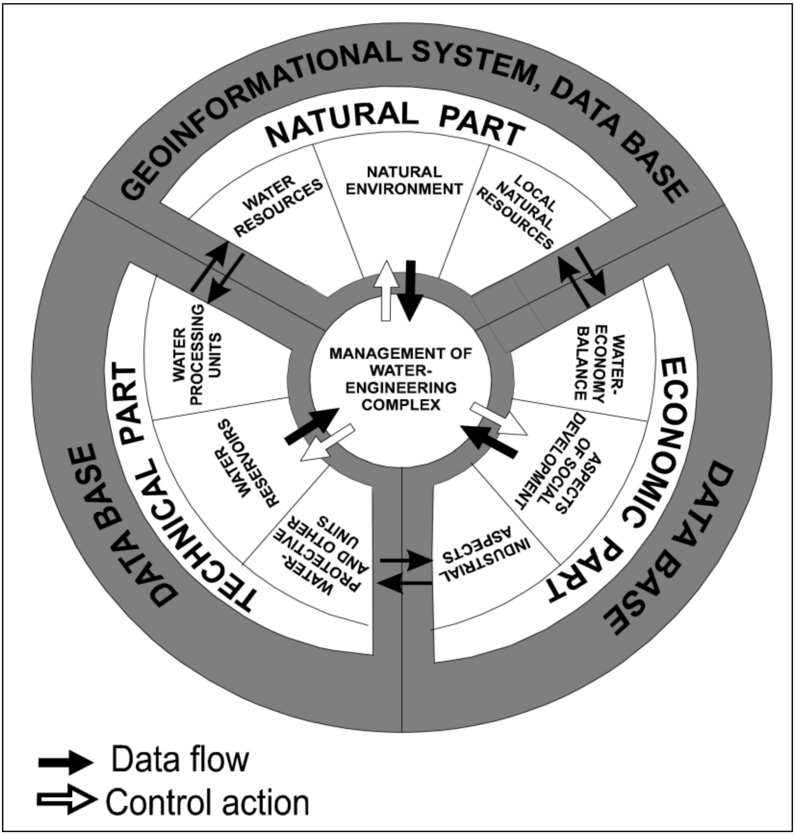

Fig. 1.1. Structure of the water-economy complex

The natural component of water-engineering unit is based on water resources. These resources are mainly of stochastic character. The runoff has seasonal and multiannual fluctuations, with shifts from wet to dry years and so on. As rule water bodies include reservoirs for seasonal and multiannual regulation of the river discharge so as to provide for reliable water supply to water users.

WEC can be classified on the basis of the following attributes:

- number of users (excluding municipal water supply) of single- and multi-branch;

- degree of the river flow regulation – with one or cascade of reservoirs;
- number of river basins in WEC – basin or interbasin river water transfer.

Figs. 1.2 demonstrate WEC's classification diagrams with indication of possible negative impacts on the environment.

Development of social and industrial infrastructure in the region, and transfer to intensive agriculture demand development of regional WECs. New reservoirs and soil reclamation units augment technogenic pressure on the natural part of WEC. When WR in one basin are lacking, water is transferred from other river basin, leading to higher stress in the environment. As a result, it should be reasonable to create a water-protective complex within the WEC for support of natural and economic situation in the water body on a necessary level of the water quality and quantity.

1.1.2.2. Water needs, demands, and users in municipal economy

Water needs, demands, and users in towns and dwelling areas

The main aim of WEC consists in satisfaction in water of all types of water users functioning within the complex. By the character of water use, users may be subdivided with a certain degree of arbitrariness into water consumers and water users.

The main aim of WEC consists in satisfaction in water of all types of water users functioning within the complex. By the character of water use, users may be subdivided with a certain degree of arbitrariness into water consumers and water users.

Among water consumers there are municipal water supply enterprises, industrial and agricultural industries, abstracting water from streams, water bodies, aquifers. There are also irreversible losses of water from evaporation and as a result of inclusion in the manufactured products.

Water users are not abstracting water from the water body. Among them there are hydropower stations, aquatic transport, etc. To the same category may be referred fish farming, aquatic recreation and tourism.

It is necessary especially to mention such category of water use as the water discharge to water bodies after a certain degree of treatment. Actually such process contradicts the water use processes. To smooth out such contradiction it is necessary to treat effluents discharged to the water body to a rather high degree of purity, allowing development of self-purification processes in the water body.

Non-point discharges of storm waters from industrial and municipal areas are creating a great threat to the water quality in natural water bodies. Such «slug» loads of pollutants create additional difficulties in the WEC management.

Each water user/consumer is giving its own demands as to the quantity and quality of water. Such demands are often contradictory, and to satisfy these demands are the main tasks of the WEC. At that rational and sparing use of water is the primary aim. To provide water of a necessary quality it is usually necessary to pre-treat it at local or centralized water treatment stations.

Water needs, demands and users in municipal economy and its features

To provide population with a necessary volume of water of satisfactory quality is the most important task of the municipal engineering. The level of water supply is among most important indices of the population well-being and health. At present almost 50 per cent of the world population has no reliable sources of potable water supply.

Municipal water supply should provide water for drinking, cooking, and sanitary purposes (washing, cleaning, etc.). Municipal water is often used for streets and parks watering, car washing, at construction sites, etc.

Annual water use in the municipal water supply is distributed as follows:

- household use – 56 %, including cooking and drinking (30 %), laundry (10%), bath/shower (30 %), water-closet (30 %);
- commercial/municipal – 17 %;
- industrial needs – 16 %;
- fire prevention – 3 %;
- plants watering, fountains – 1 %;
- other needs – 5 %.

Properties and composition of water from any source and with any means of supply should provide for:

- epidemiological safety;
- safe chemical composition;
- good organoleptic properties (smell, taste).

Municipalities as water consumers present strict demands to physical (temperature, transparency, coloration, smell, taste) and chemical indices (acidity, hardness, lead, iron, and other elements content), and also sanitary and hygienic demands (absence of pathogenic microorganisms and viruses).

Potable water use and waste water discharge are very irregular during day, but practically regular during year as a whole.

Seasonal fluctuations in water demand are within 15-20 %. Medium daily water use is determined as product of specific water use q_{sp} and design number of population N by formula:

$$Q_{av.d.} = \sum \frac{q_{sp.} \times N}{1000}, \text{ [m}^3\text{/day]} \quad (1.1)$$

where:

$q_{sp.}$ – specific water use (use standard), l per day per capita;

N – design number of population.

Average annual use is determined by the number of daily use.

To allow for maximum and minimal use during the day period, irregularity of water use coefficients are applied.

$$Q_{day\max} = K_{day\max} \cdot Q_{dayav.} \quad (1.2)$$

$$Q_{day\min} = K_{day\min} \cdot Q_{dayav.} \quad (1.3)$$

These coefficients take into account the daily routine of population, work day period, and degree of building amenities, water use fluctuations in days of week and year seasons. K values fluctuate within:

$$K_{day\max} = 1.1...1.3;$$

$$K_{day\min} = 0.7...0.9;$$

It should be noted that qualitative demands to municipal water are highest for potable water and lowest for car washing and water-closet flush. It can provide for qualitatively two-level water supply – if the building is equipped with necessary fittings. But all the same sanitary quality of the second-rate water should correspond to that of the first-rate water, as there are possible cross-connections, etc.

Under conditions of ever aggravating water shortage it is very important to solve the problems of water saving. For this purpose can be applied reduced norms for water use by application of waterless technologies, by precluding the use of potable water for technical needs, by cutting down water leakages and water line damages.

Water used by municipalities is polluted with organic and mineral pollutants, with chemical compounds. It is discharged to sewerage lines either separately or with industrial waste and storm waters.

Waste waters are breeding media for bacteria and viruses, including pathogenic ones, they may contain toxic compounds. As a result, waste waters create threat for people and environment. So every living area has to be provided with a system for collection, transportation, treatment and disposal of treated waste waters. Such system is called the drainage system of the dwelling locality. Such system is a very important component of the water-engineering complex.

Municipal waste waters, industrial and storm waters are of different compositions and they demand different methods of treatment. But in some cases joint treatment may be technically and economically profitable. There are the following types of drainage systems:

- combined system, for transportation of sanitary, industrial and storm waters;
- completely separate drainage systems for each category of waste water. At that the treated storm water can be reused for technical water supply;
- semiseparate drainage system, i.e. for municipal and industrial waste waters and for storm waters flowing in shoots and ditches.

There are also combination systems, with a part of combined discharge and a part of separate discharge for storm waters.

Water needs, demands, and users in urbanized areas and megalopolises

Demographic explosion in XX century has been accompanied by intensive growth in city population. Urbanization index (i. e. relative part of town dwellers) has augmented, leading to a new ways of living.

In Europe on 1.01.1995 the total population was 750 billion people. Of them 535.7 billion (71.4 %) were living in cities and towns.

In the world there are several megalopolises, as example the so-called «delta-polis» Amsterdam-Brussels-Cologne with population over 50 billion people, in UK «midland» Liverpool-Manchester-Leeds-Bedford-Birmingham with population about 15 billion people.

In developing countries the growth of city population proceeds in explosive manner. The poorest population is going on to cities without any state control. And suburbia are transforming into poverty belts with acute social problems, including problems of water supply and drainage.

In urbanized territories the problems of water engineering are getting very involved due to augmentation of water usage and continuous necessity to construct new water and sewerage lines. Also there are problems with storm and melt waters drainage. City water bodies must be provided with protective bank zones, free of any commercial activities. At that, city rivers and water bodies should have sufficient depth and water flow rate to support satisfactory ecological conditions and possibility to create recreation and green zones.

Concurrently with centralized systems for population water supply should develop decentralized ones, such as sale of bottled water, etc.

Decentralized water supply from deep wells has the following advantages:

- potable water supply is self-sufficient, free of emergency situations;
- additional source of water supply provides for its reliability;
- high quality artesian water is used sparingly;
- cost of water treatment is lower in comparison with processing of water from surface sources.

Urbanized territories should be free of resource- and water-intensive industries, which it would be reasonable to concentrate in industrial zones, as it is done in the Tokyo megalopolis.

1.1.2.3. Water needs, demands and users in branches of the economy

Water supply of industries

Industries are among the largest water users in the country, and their demands as to quantity and quality of water are multifarious. Volumes of over-the-year available water of suitable quality is very important factor for selection of an industrial site. For industrial water supply are characteristic such features as steady water demand through the year, wide spectrum of used water pollutants and large volumes of abstracted water. At industries there are also sanitary and hygienic needs in water for personnel, and also needs in water for fire prevention.

Quantities of water use for industrial needs are fluctuating in wide limits, depending upon the type of production and manufactured products. Comparative efficiency of water use in the same branch of industry is determined with the help of specific water use indexes. The present-day technologies use the following volumes of water (in m^3) per one tone of manufactured product: cast iron – 160…200; steel – 150; rolled steel – 10…15; nickel – 4000; copper – 500; synthetic rubber – 2000…3500; synthetic fiber – 2500…5000; nitrogenous fertilizers – 600; cotton cloths – 300…1000; paper – 400…1000.

Depending upon technology used at an enterprise, the use of water may be several fold greater than at other enterprises manufacturing the same product. Large industries using great volumes of water are usually situated near sources of water because its transportation demands high expenses.

Under conditions of water deficit, lowering of water abstraction is important not only economically but also ecologically. Therefore in industry are widely applicable re-use of technological water. The flow-through technological scheme of water supply is the simplest and most water-intensive (Figs. 1.3, 1.4). Here once-through water goes to treatment units and then is discharged to a water body. Such schemes are applicable under conditions of water abundance and/or for low water-using industries. In all other cases it is necessary to apply recycling or consecutive use, or combined systems of water supply. Here water is reused many times after treatment to a necessary standards of quality. As a rule, any technological process leads to irretrievable loss of 2 to 5 % of water. So it is necessary to replenish the recycling system with fresh water of corresponding quality. Recycling leads to a considerable economy of water and practically everywhere is economically profitable. Under a consecutive scheme of water use, water used in one process is reused after corresponding treatment, in other processes. In some cases used water can be directly utilized as carriage water for removal of cinder, scale, slag, etc. In many industries, under acute shortage, water can be reused up to 10 to 14 times.

Industry is the third largest user of water, – after agriculture and thermal power engineering – and therefore sparing use of water resources is a must at groups of and at separate industrial enterprises.

Efficiency of the water resources use at a WEC can be characterized by the following criteria:

- specific norm of water use per unit of a manufactured product;
- volume of abstracted fresh water;
- volume of water in the water recycling system;
- volume of waste waters incoming to treatment units;
- volume of waste waters discharged to a water body;
- composition and quantity of pollutants in discharged treated waste waters;
- water reuse in industrial processes;
- impact of the water-engineering complex on the environment and water bodies, on their capacity for recreating and fish farming;
- a degree of the water body protection against anthropogenic and technogenic impacts;
- social, economic, ecological and technical efficiency of the water body protection.

For attainment of efficient use of WR at an engineering enterprise it is necessary:

- application of dry technologies, leading to lower volumes of water use and waste waters generation;
- application of multiple reuse of water in technological processes;
- application of effective methods of waste waters treatment, giving maximum removal of pollutants;
- subdivision of the water-engineering system into local closed-cycle subsystems for technical water supply;
- application of modern technologies for removal and utilization of useful components from waste waters and for sludge treatment;

- high degree of reuse of treated industrial and municipal waste waters in agriculture, forestry, etc.

Efficiency of water use at an industrial enterprise is evaluated by the coefficient of water use (K_u); by the coefficient of water recycling (K_r), by the coefficient of irretrievable loss of water (K_i):

$$K_u = \frac{Q - Q_{ww}}{Q} \times 100\% \tag{1.4}$$

$$K_r = \frac{Q_r}{Q_r + Q} \times 100\% \tag{1.5}$$

$$K_i = \frac{Q - Q_{ww}}{Q_r + Q} \times 100\% \tag{1.6}$$

where:

Q – rate of fresh water abstraction (m^3/hr);

Q_{ww} – volume of waste waters;

Q_r – volume of recycled water.

Approximate values of K_r are as follows: power engineering – 65%, fuel industry – 82 %, ferrous metallurgy – 85 %, non-ferrous metallurgy – 80 %, oil processing – 86 %, machine building – 70 %, pulp and paper manufacture – 65 %, light industry – 60 %, food industry – 45%.

It should be noted that in food processing and in pharmaceutical industry quality standards for water are especially strict. And here water reuse can be applied only at auxiliary processes.

The water use intensity by the industry is characterized by the complete volume of water use (W_c). W_c is equal to the sum of fresh water abstraction (W_f) and that of recycled water (W_r):

$$W_c = W_f + W_r \tag{1.7}$$

The irretrievable loss of water in the industry consists of the volume of water included in the manufactured product and losses during manufacturing processes, transportation, and as a result of waste water incineration or evaporation or pumping in an underground horizon. For example, in water-drive oil production water is irretrievably lost as a result of pumping into strata.

In the system of recycled water supply irretrievable losses are greater (up to 12 %) than in the flow –t hrough systems (about 2 %).

Efficiency of recycled water supply is determined by the multiplicity of water reuse (n), i. e. the ratio:

$$n = \frac{W_c}{W_f} \tag{1.8}$$

and the water recycling coefficient (K_r):

$$K_r = \frac{W_r}{W_c} \tag{1.9}$$

In industries demands to water quality are multifarious. They depend upon technological operations.

Such factors as availability of water, its quantity and quality contributed to wide application of water in technological processes. The largest volumes of water are used for cooling (about 70 %), for extraction (15-20 %) and for transportation (10-15 %).

Use of water for power generation

Energy potential of water is used with the help of water reservoirs, accumulating river water for pressure generation and volume of water. At that the hydroelectric plant energy power (N) is defined by a simple formula:

$$N = \frac{\rho g Q H}{\eta} \tag{1.10}$$

where:

ρg – 9.81 kN/m^3;

Q – water discharge, m^3/s;

H – water head pressure, m;

η – efficiency coefficient.

In mountain rivers with high grade, reservoirs are usually of small volume. Water goes by tunnels to a turbine unit situated at much lower level. Such arrangement provides for high pressure H, generated large amounts of electricity even at small values of Q.
Such hydroelectric plants are called pressure derivative ones.

At lowland, high-flow rivers the height of dam can be of scores of meters. And this provides at relatively low pressure for high Q rate, ensuring generation of great amounts of electric power.

The rate of water use for internal needs of the hydroelectric plant (cooling of units, washing of premises, potable needs, etc.) is insignificant, and is provided for from the reservoir.

Lowland water reservoirs are serving as multipurpose water bodies. They satisfy water needs of various municipal and industrial enterprises, which often have contradictory demands to regimes of water use. As a result, the agreement of power generating demands with that of other water users often becomes the main task of the WEC.

Thermal and atomic power stations are among the greatest water users. Exhaust-steam condensers of steam turbines are using the greatest amounts of water. Much less water is used for cooling other units of the power station. At the atomic power station for insurance of uninterrupted supply of cooling water to nuclear reactors there are three autonomous systems of cooling water supply. At that, cooling water can be recycled through spray basins, cooling towers, and cooling reservoirs.

The through-flow cooling system is used only when sea water is applied for this purpose.

At thermal power stations the main volume of cooling water is used for steam turbine condensers cooling. This water, after treatment, is used for boiler feeding. The rate of water use for additional feeding of boilers amounts to 1-2 % of the steam generation rate. Specific use of cooling water per 1 kW of installed capacity is going down when turbine power is increasing. At turbine power 100000 kW and 500000 kW and steam pressure 9 MPa and 24 MPa specific rate of water use per 1 kW of installed capacity is 0.17 m^3/hr and 0.1 m^3/hr, correspondingly.

Total rate of cooling water flow at powerful electric stations amounts to 200 m^3/s and higher. Total rate of water flow at modern thermal power stations of 8x300000 kW (8 blocks 300000 kW each) capacity amounts to about 300000 m^3/hr in summer time. Therefore usually water recirculation cooling systems are used with heated water going to a cooling pond or to a cooling tower.

At coal-heated power stations water is also used for hydro-removal of cinder and slug to dumps.

Water supply of agriculture

Agriculture is the largest user of water. About 90 % of water in agriculture is used for irrigation and impounding, and 5 % for rural water supply, for cattle farms, etc is used about 4 %, and only 1 % is used for household needs. These percentages are subjected to shifts depending upon geographic and climatic conditions, and structure of agriculture in a given region.

The volume of water used for rural population supply is determined on the basis of 150-200 l/day per capita, depending upon a level of available amenities.

In agriculture, provision of lands with water is the one of the most important tasks. Therefore in semiarid zones and in regions with humidity shortage water amelioration is performed. This process allows obtaining high yields on low fertility lands. In the USA 18 % of tilled areas are irrigated, in Italy 21 %, in Bulgaria 28 %, in Rumania 22 %, in Ukraine 17.75 %.

It is possible to use for irrigation local non-point discharge, as well as water from rivers, lakes, aquifers, etc, selection of the source of water depends upon the level of costs, technical factors, and the water body capacity and water quality in it. For irrigation and watering a high degree of water volume fluctuations during vegetative period is characteristic. The year aridity also strongly impacts the amount of water. In insufficiently moist zones shortage of water for grain crops during an average dry year amounts to 48-80 %. At mean annual precipitation 300 to 500 mm, 1 ha obtains 3000 to 5000 m^3 of water, and for some dry land cultures it is sufficient. But precipitations during vegetative period are distributed irregularly. Irrigation should be applied only when it is necessary due to lack of natural precipitations. At irrigation the degree of non-returnable use of water may amount to 75 % of the abstracted volume.

Amounts of water necessary for irrigation should be computed on the basis of water availability during dry years. At that computations are to be performed separately for areas with irrigation network and with irregular movable network.

The irrigation network consists of the main water abstraction unit at the donor water body, major canals, minor canals, furrows, discharge canals with corresponding units, and drainage network for washing irrigation.

Fig. 1.5 illustrates a diagram of irrigation system with a network of various canals, pumping stations, guard dams, erosion preventive hydrotechnical units, lines of communication and power supply. Small areas can be irrigated with a pipeline system, without canals.

Quantity of water used during vegetative period depends upon a type of crop, climatic conditions and soil fertility.

It should be noted that increase in water availability leads to a crop increment only to a certain limit. Increment in water supply above that limit leads to a lower crop.

The amount of water delivered to the irrigated area during the whole vegetative period (q_0) is called the irrigation rate, m^3/ha and is depended on transpiration (the loss of water vapour from plants) T, evaporation E, precipitations Q, humidity storage in the soil ΔQ:

$$q_O = T - Q - \Delta Q + E \qquad (1.11)$$

The irrigation rate should be determined for each region, with allowance for all these factors.

On average, irrigation rates for various crops are fluctuating within limits indicated in Table 1.3.

Table 1.3.

Irrigation rates for crops (m^3/ha)

Native zone	***Vegetable crops, forage grass***	***Grain crop***
Non-chernozem	1000…2000	-
Wooded steppe	2000…3000	1000…2000
Steppe	3000…5000	2000…4000
Desert	7000…9000	5000…6000

Irrigation rate for the same crop is increasing with movement along the southerly direction. On average the irrigation rate (without evaporation and filtration losses) amounts for cotton 5000 to 8000 m^3/ha, grain crops 1500-3500 m^3/ha, perennial grasses 2000-8000 m^3/ha, rice 8000-15000 m^3/ha. Actually the irrigation rate would be higher when evaporation, filtration, and irrigation network leakages would be taken into account.

Total irrigation rate is subdivided into several subrates, determined in accordance with actual conditions, soil features, irrigation method, the crop type, etc.

Within the last years, under conditions of water shortage, treated waters are used for irrigation. Such irrigation is used in particular at specialized fields, under corresponding soil and climate conditions. At that it is necessary to ensure removal of pathogenic bacteria and viruses from the waste waters. Also they should be free of heavy metals. For irrigation the most suitable are waste waters of food industries such as sugar, yeast, beer factories, and also waste waters of stock farms, after corresponding treatment. Heated water of power station cooling ponds also is used for irrigation, after cooling to a corresponding temperature.

Progressive methods of irrigation, such as subterranean and drop irrigation are used for reduction of volumes of water. But such progressive methods need much higher monetary investments. In dry regions, pastures are irrigated, often with the help of irrigation systems, and with groundwater application. Irrigation water is also used for animals' watering where there is no suitable natural water body. Such watering points can serve pasture areas of several different square kilometers.

There are irrigation systems with a drainage network used for irrigated land washing to prevent its salinization. Washing water is usually discharged to a water body.

On wetlands used for agricultural production, soil deaquation is applied. There are lands with permanent and temporary super humidity. Gentle slopes and flood plains of rivers are temporary over wetted during freshets and floods. Permanently over wetted are lands fed with pressure groundwater, and also bogs, flooded territories around water reservoirs. Land deaquation can be attained by acceleration of non-point discharge, reduction in groundwater level, capture of slope discharge delivered to the land under deaquation and by regulation of freshet and flood regimes.

The deaquation system usually consists of regulating, fencing, and flow-through networks, water catching units, hydraulic structures (Fig. 1.6), and protecting forest. In the territory water balance computation it is necessary to take into account water used for irrigation and water delivered to the water body by deaquation system.

Water usage by water transport

Water transport is an intensive user of internal water bodies (large and medium rivers, lakes, reservoirs, near-shore sea areas). Water transport is 2.5 to 3 times lower in cost than railway transport and 10 to 15 times than road transport.

Improvement and reconstruction of internal water ways is as a rule connected with regulation of river flows, hydroelectric complex cascades construction, with discharge locks. It means that water transport is most important part of the WEC, and it serves as a connecting link in interstate water engineering relationships, e.g. the Danube river.

Upkeep of the necessary water depth regime in regulated rivers is connected with water flashes. And flashes are impacting first of all the electric power generation process, and water abstraction for municipal and industrial needs.

Water transport has no influence on water quantity in the water body. But water flashes reduce water level in the reservoir, leading to reduction in electric power generation.

Internal aquatic ways should be provided with such technical units as ports, moorages, sluices, etc.

Ports should provide watercraft with water for their own needs. Washing and cooling water is abstracted directly from the water body. Water used for fuel tanks washing should be pumped to waste water treatment units.

Watercraft can operate in a water body with any water quality.

Watercraft can pollute water with oil products and wastes. So it is necessary to prevent waste dumping from ships.

Fish husbandry

Fish husbandry and fishing in internal waters and open seas are very important sources of food.

Efficient fish farming demands a range of actions impacting water sources. Among them there are the following:

- maximum reduction in natural waters pollution;
- upkeep of optimal depths in water bodies with the help of special regulating units;
- reconstruction and installation of new fish-ways on rivers with commercial fishing;

- enhancement of fish farming efficiency at existing and new reservoirs with the help of ameliorative actions;
- provision on rivers of corresponding water regime conducive to spawning of valuable fish breeds;
- provision of favorable conditions for valuable fish breeding in lower reaches of the river by flow augmentations, and by construction of special units;
- creation of fish husbandries on small (non-navigable) rivers and river flood plains (fish husbandry scheme is given in Fig. 1.7);
- further development of fish ponds, including cooling ponds of power stations;
- construction of fish-protecting units at all water intakes on rivers, lakes and reservoirs.

So, the fish husbandry demands to natural water quality and quantity are rather strict. It demands certain regime of water levels and water releases from reservoirs, and also construction of special fish-ways in dams.

Recreational waters

Recreational use of water, i.e. creation of sites for curation, recreation and sport on rivers, lakes, reservoir and sea beaches, is among most important types of water usage in the water-engineering complex. Amelioration and improvement of banks and coastlines also can be considered as aquatic recreation. Also use of mineral table and curative groundwaters can be considered as a type of recreation.

The area of the recreation zone can be determined on the basis of a recommended load on the beach (or bank), e. g. 5 m^2 per person on the sea shore, 4 m^2 per person on children's beach. At that it is necessary to take into account a coefficient of concurrent load on the beach. It is 0.4 for sanatoriums, 0.8 for climatic health resorts, and 0.9 for rest homes.

Recreational water bodies should have water of high quality, especially at sites for swimming and sport fishing. It is forbidden to discharge industrial and/or municipal waste waters near recreational zones. Bottom and shore/bank zones should be periodically cleaned-up. A scheme of recreation zone is given in Fig. 1.8.

Rates of water use in medical establishments and sanatoriums are 400…800 l per day per capita, and in swimming pools 100l per day per capita.

Rates of water use per person per day at stadium and sport halls is up to 50 l, and per one member of the audience up to 3 l.

Efficiency of the recreational water use is rather high.

Use of existing recreational zone and creation of new ones demands implementation of environment protective measures, improvement in sanitary and epidemiologic situation. Enrichment of landscapes is directly connected with problems of surface and ground water protection.

1.1.2.4. Demands of water users to water quality

Finding a balance between actual quality of natural waters and water users' demands to the quality is one of the tasks of designing and managing the water-engineering complex. Such contradiction can be solved with the help of water treatment plants installed after water intakes. Such plants can process abstracted water to a standard necessary for a given water user. It is clear that anthropogenic and industrial load on the water body is strongly impacting the water quality. And a degree of waste water treatment before discharge to the water body is among the strongest water-quality influencing factors.

When selecting a water body for water supply of a certain water user it is important to consider the water quality and its seasonal fluctuations.

The quality of natural water is characterized by physical, chemical, sanitary, and biological indices. Values of these water quality indices have to match with demands of water users.

Natural waters can be subdivided into the following groups:

- drinking water, and water for aquatic recreation;
- water for industrial processes;
- water for steam boilers.

For each of these groups there are typical qualitative demands. The most strict qualitative requirements are applied to drinking water, and the least strict to water injected to non-productive oil wells.

In various countries are used their own standards for water quality. If water quality in surface water bodies, and sometimes that of ground water, does not satisfy established standards, it should be treated at water processing stations.

Standards for potable water

In Ukraine, Bielorussia, Russia and Moldova demands to potable water are given in the State Standard «Drinking Water». In EU countries is functioning Council Directive 75/440/EEC, outlining demands to surface water abstracted for potable needs. EU countries are obliged to classify their water bodies and provide qualitative monitoring of water. There are 50 indices of water quality. These indices (standards) are subdivided into two groups – indications of maximum permissible contaminant levels. Such standards are enforceable and there are recommended values of the contaminant content. These values are non-enforceable. For potable water supply can be used water from water bodies of qualitative categories A1, A2, A3. In the Directive are given physical, chemical, and microbiological characteristics used for qualitative subdivision of water. Potable water quality is determined in the normative document 80/778/EEC, COM (gu) 6/2 final 95/10 (SYN).

Directive 79/869/EEC determines standard methods for analysis of surface waters used in EU for potable water supply. In USA in 1972 was adopted the Clean Water Act (PL 95-217), with indication of maximum permissible levels of contaminants, safe for public health.

In Ukraine, Bielorussia, Russia and Moldova demands to potable water are given in the State Standard «Drinking Water»(DSanPiN 2.2.4-171-10). In EU countries is functioning Council Directive 75/440/EEC with amending acts 79/869/EEC and 91/692/EEC, outlining demands to surface water abstracted for potable needs. EU countries are obliged to classify their water bodies and provide qualitative monitoring of water. There are 50 indices of water quality. These indices (standards) are subdivided into two groups – indications of maximum permissible contaminant levels. Such standards are enforceable and there are recommended values of the contaminant content. These values are non-enforceable. For potable water supply can be used water from water bodies of qualitative categories A1, A2, A3. In the Directive are given physical, chemical, and microbiological characteristics used for qualitative subdivision of water.

Potable water quality is determined in the normative document 98/83/EC.

Directive 79/869/EEC amended by 81/855/EEC, 91/692/EEC and the Council regulation (EC) No 807/2003 determines standard methods for analysis of surface waters used in EU for potable water supply. In USA in 1972 was adopted the Clean Water Act (PL 95-217), with indication of maximum permissible levels of contaminants, safe for public health.

Requirements to water quality for industrial water supply

In this area the scope of qualitative demands to water is very wide.

Quality of water used in industrial processes acts on the quality of manufactured products, on equipment longevity, and so on. The most strict qualitative demands are presented to water, forming a part of manufactured product. Water used for other purposes should satisfy standards on hardness, incrustation capacity, foaming, aggressiveness, etc. The least qualitative demands are to water used for cooling and hydraulic transport. But it should not corrode metals and/or concrete, lead to biofouling of cooling units.

There are specific demands to water quality at various branches of industry. For example, water used for manufacture of photographic papers and films should be free of manganese, iron, etc. Water used for ore enrichment should be free of large solid particles. Water is often used in closed cycles for cooling. It should be free of iron, rough suspension, and organics. It should contain steady amounts of carbonic acid and calcium carbonate, for prevention of scale formation in cooling units.

Some industries demand water of very high purity, i.e. it should satisfy standards much stricter than that for drinking water.

Requirements to water used in agriculture

Here the necessary level of water quality depends upon the aim of water use. For fowl, animals and livestock watering water of potable quality should be used. At that it is possible to use for watering water with elevated salt content, if there is a permission of Veterinary Service.

In agriculture main volumes of water are used for irrigation. Qualitative demands to irrigation water depend upon irrigated soils and irrigation technique. It is necessary to ensure prevention of soil salinization, especially with magnesium and sodium sulphates, sodium chlorides, etc.

Soil salinization would lead to high demands in water used for soil washing.

Requirements to water quality in fish farming

Fish farming needs water of high quality in water bodies used for production. Such factors as temperature, dissolved oxygen, absence of toxic substances are of special importance. Cooling water of power stations is suitable for fish production in special fish culture units.

Directive EU 78/659/EEC on fresh water quality demands observation of norms of maximum contaminant levels in water bodies used for fish farming.

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Directive EU 78/659/EEC amended by 91/692/EEC and the Council Regulation (EC) No 807/2003 on fresh water quality demands observation of norms of maximum contaminant levels in water bodies used for fish farming.

Requirements to recreational waters

Water intended for recreational usage must have quality providing for safety of swimmers. Directive EU 76/160/EEC demands observation in fresh and sea water used for recreation of 13 obligatory qualitative indices (mainly microbiological and physical-chemical). In Ukraine, Russia, Belorussia, and Moldova there is a State Standard on recreational water quality in water bodies. It demands observation of eight indices: smell, taste, coloration, pH, dissolved oxygen, organic substances, toxic chemical compounds, and coli index.

Water intended for recreational usage must have quality providing for safety of swimmers. Directive EU 76/160/EEC amended by 91/692/EEC and the Council Regulation (EC) No 807/2003 demands observation in fresh and sea water used for recreation of 13 obligatory qualitative indices (mainly microbiological and physical-chemical). In Ukraine, Russia, Bielorussia, and Moldova there is a State Standard on recreational water quality in water bodies. It demands observation of eight indices: smell, taste, colouration, pH, dissolved oxygen, organic substances, toxic chemical compounds, and coli index.

1.1.2.5. Ecological aspects of the world water resources exploitation

The global ecosystem of the planet can be presented as a hierarchy of ecosystems lower order, including ecosystems of land, separate geographic zones, landscapes, and so on. Also it is possible to consider ecosystems of seas, reservoirs, rivers, and separate segments of river, i. e. aquatic ecosystems or water ecosystems.

Water users, water consumers and the WEC as a whole are impacting water resources and aquatic ecosystems in the following way:

- by abstraction of considerable volumes of water from natural water bodies. Non-returnable use of water in EU countries amounts to 5…10%, while in U.S.A., Ukraine, and Russia it is about 10 to 20 % of abstracted water;
- constructed reservoirs and ameliorated land tracts are transforming water balance in a given territory. Fell of forest leads to lower evaporation. In towns there is a specific water regime caused by lower infiltration of water and pumping of groundwater. On the other hand afforestation is acting positively on the water balance. Forest strips are catching freshet waters and snow;
- construction of reservoirs leads to shifts in regime of drifts. It also demands flooding of large land territories. High degree of evaporation from the reservoir surface leads to decrement in the amount of regional water resources. And it leads to elevation of groundwater and under flooding of large territories;
- groundwater regime is altered;

- large volumes of pollutants are inflowing with poorly treated waste waters. Industrial waste waters are the main source of pollution of natural water bodies. Waste waters of oil processing factories, chemical, metallurgical, ore mining plants are especially harmful. Intensification of agricultural production leads to constantly increasing application of fertilizers and agricultural chemicals. These compounds are washed off the soil and delivered to water bodies with non-point discharges from the fields. Municipal waste waters are also strongly polluted;
- regime of municipal non-point discharges and degree of their pollution are changed.

There are also indirect impacts of the WEC on water resources and natural environment, such as:

- changes of natural vegetative composition and landscapes;
- generation of acid rains as a result of atmosphere pollution;
- distortion of geophysical regime of territories, their under flooding, slide processes intensification.

And moreover, water is used squanderingly in factories and municipalities. Negative effects on water resources can be intentional and unintentional. So, intentional negative impacts are connected with growth of population, agricultural areas, industries. Unintentional impacts are caused by soil impoverishment on large areas, deforestation, soil salinization.

A set of water-protective measures is an obligatory component of the water-engineering complex.

In EU and other developed countries energetic measures and actions are directed at elaboration of legislative and normative documents intended for protection of water resources against pollution and/or depletion. Such activities are considered as an integral part of the environment-protecting policy.

1.1.2.6. Water resources depletion

Total volume of water resources on the Earth is practically constant. But the problem of water supply, and especially with water of potable quality, is getting ever more acute, concurrently with aggravation of the ecological crisis. Growth of population, so-called demographic explosion, concurrently with growth of agriculture and industry, leads to shortage in fresh water resources which are being noticeably degraded and depleted.

There is a distinction between quantitative and qualitative depletion of the water resources. Water resources of the world in principle are inexhaustible. But the water cycle and its separate components are distorted by human activities, and this leads to redistribution of water volumes in the water cycle components. And correspondingly there are shifts in available and easily available resources of fresh water. It means that quantitative depletion of water resources (i.e. reduction in volumes of water available for human needs) is caused by redistribution of water volumes at separate water bodies in the process of water cycling, leading to decrement in available volumes of water.

Feeling of forests in the watershed area created situations in which storm and melt flow goes directly to the river bed, as these are no forest canopy and debris layer able to catch the storm flow. Water infiltration into aquifers is decreasing, and maximum probable floods are increasing. In addition to extreme ecological situations which were in Carpathian Mountains, during drought periods rates of river flow are decreasing.

Water abstracted from the water body for crop irrigation is used for evaporation and vegetal discharge (transpiration). So, water from the river link of the water cycle is transferred to the soil and atmospheric links, and only part of it returns to the river. And, as a result, increases shortage of water usable for municipal and/or industrial supply in a given region. As a rule, water transfer to other links of the water cycle acts negatively on the water resources. Water used for various purposes remains in the water cycle, but either in other form or in transformed state, or in other link of the cycle, or in other part of globe.

Abstraction of river water for water supply causes non-returnable loss of water (from 5 to 10 %), and return water (90-95 %) is of worse quality. And this leads to deterioration of the river water because effluents as a rule are not treated to the level of the river water quality. And this leads to qualitative depletion of water resources.

Yet another large source of water body quality deterioration is washing-off of agricultural chemicals and fertilizers from agricultural land areas. Atmospheric link of the water cycle generates strong negative impact on quality of water resources. Atmospheric effluents from various sources of sulphur, nitrogen and other oxides, lead to formation of acid rains and water quality deterioration in water bodies.

Reservoirs also receive large amounts of suspended solids, chemical compounds and organic substances. And harmful chemicals are accumulating in ichthyofauna. Nitrates inflowing to reservoirs are reduced to more toxic nitrites, which in combination with secondary amines are forming nitroamines, able to cause serious morbidity.

Groundwater resources are also subjected to qualitative depletion. Lagoons for industrial waste waters are sources of pollutants infiltration to groundwater.

The problem of water resources protection against depletion and pollution is among the main in the problems of water resources management.

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EXERCISES

Exercise 1.

It is known:

the rate of fresh water abstraction Q = 800 m^3/ha, volume of waste water Q_{ww} = 650m^3/ha, volume of recycled water Q_r = 300 m^3/ha.

Calculate the coefficient of water use K_u, of water recycling K_r, of the irretrievable loss of water K_i:

K_u	12.05 %	18.7 %	26.8 %	39.7 %
K_r	27.2 %	30.7 %	38.5 %	43.0 %
K_i	5.5 %	9.7 %	11.0 %	15.7 %

Exercise 2.

It is known:

for concrete water economy complex the total complex volume of water use W_c = 120000 m^3/day,
volume of water abstraction from water sources W_f = 80000 m^3/day,
volume of recycled water W_r = 40000 m^3/day.

Calculate the multiplicity of water reuse n and water recycling coefficient K_r:

n	0.5	1.0	1.5	2
Kr	1/5	1/3	1/2	

Exercise 3.

It is known:

design number of population N = 50000, specific water use q_{sp} = 250 l/day per capita, the design coefficients of water use irregularity due to the day period $K_{day\ max}$ = 1.2, $K_{day\ min}$ = 0.8

Calculate the design max $Q_{day\ max}$ and min $Q_{day\ min}$ water use during the day period.

Qday max	10000 m3/day	12000 m3/day	15000 m3/day
Qday min	8000 m3/day	10000 m3/day	12000 m3/day

Exercise 1. – Solution

It is known:

the rate of fresh water abstraction Q = 800 m^3/ha,

volume of waste water Q_{ww} = 650m^3/ha,

volume of recycled water Q_r = 300 m^3/ha.

Calculate the coefficient of water use K_u, of water recycling K_r, of the irretrievable loss of water K_i:

K_u	12.05 %	18.7 %	26.8 %	39.7 %
K_r	27.2 %	30.7 %	38.5 %	43.0 %
K_i	5.5 %	9.7 %	11.0 %	15.7 %

Solution:

$$K_u = \frac{Q - Q_{ww}}{Q} \cdot 100\% = \frac{800 - 650}{800} \cdot 100 = 18.7$$

$$K_r = \frac{Q_r}{Q_r + Q} \cdot 100\% = \frac{300}{300 + 800} \cdot 100\% = 27.2$$

$$K_i = \frac{Q - Q_{ww}}{Q_r + Q} = \frac{800 - 650}{800 + 300} = 11.0$$

Exercise 2. – Solution

It is known:

for concrete water economy complex the total complex volume of water use W_c = 120000 m^3/day,

volume of water abstraction from water sources W_f = 80000 m^3/day,

volume of recycled water W_r = 40000 m^3/day.

Calculate the multiplicity of water reuse n and water recycling coefficient K_r:

n	0.5	1.0	1.5	2
K_r	1/5	1/3	1/2	-

Solution:

$$n = (\frac{W_c}{W_f}) = \frac{120000}{80000} = 1.5$$

$$K_r = (\frac{W_r}{W_c}) = \frac{4000}{120000} = \frac{1}{3}$$

Exercise 3. – Solution

It is known:

design number of population N = 50000, specific water use q_{sp} = 250 l/day per capita, the design coefficients of water use irregularity due to the day period $K_{day\ max}$ = 1.2, $K_{day\ min}$ = 0.8.

Calculate the design max $Q_{day\ max}$ and min $Q_{day\ min}$ water use during the day period.

$Q_{day\ max}$	10000 m^3/day	12000 m^3/day	15000 m^3/day
$Q_{day\ min}$	8000 m^3/day	10000 m^3/day	12000 m^3/day

Solution:

$$Q_{day\max} = K_{day\max} \cdot Q_{av.d.} = K_{day\max} \cdot \sum \frac{q_{sp} \cdot N}{1000} =$$

$$= 1.2 \cdot \sum \frac{250 \cdot 50000}{1000} = 15000$$

$$Q_{day\min} = K_{day\min} \cdot Q_{av.d.} = K_{day\min} \cdot \sum \frac{q_{sp} \cdot N}{1000} =$$

$$= 0.8 \cdot \sum \frac{250 \cdot 50000}{1000} = 10000$$

COMPREHENSION QUESTIONS

1. What is the succession of tecnological operation for the provision of water consumer with fresh water and protection of water bodies?
2. What is water-economy complex (WEC)? Its structure?
3. Give an example of WEC.
4. Give characteristics of WEC of region or town where you live.
5. What is the difference between water consumer and water user?
6. What factors determine irregularity of water use during the day period?
7. What is it: flow-through supply system, water supply system with water rouse?
8. Give the main characteristics of water usage in:

a) towns; b) municipal economy; c) some branches of industry;
d) power generation; e) agriculture.

9. Try to summarize the main ecological problems of WEC.

КОНТРОЛЬНІ ПИТАННЯ

1. Яка послідовність технологічних операцій для забезпечення споживачів питтєвою водою і захисту водоймищ?
2. Що таке водне господарство ? Яка його структура?
3. Наведіть приклад водного господарства .
4. Наведіть характеристики водного господарства регіону чи міста, в якому ви мешкаєте.
5. Яка різниця між водоспоживачем і водокористувачем?
6. Які фактори визначають нерегулярність водокористування вдень?
7. Що таке проточна система постачання, система водопостачання з водопідпором?
8. Наведіть основні характеристики водоспоживання
   a) міста; b) міського господарства
   c) деяких видів промисловості;
   d) виробництва енергії; e) сільського господарства.
9. Підсумуйте головні екологічні проблеми водного господарства.

1.1.3. STRATEGY OF WATER RESOURCES MANAGEMENT

1.1.3.1. Water resources management in the context of sustainable development

Requirements for water resources management in the context of sustainable development

The 1997 Declaration of UN conference on a surrounding environment and development in Rio de Janeiro outlined the necessity of transfer of global community to paths of sustainable development, which will ensure a balance between solution of socio-economic problems and saving of the environment, provide for sufficing of the basic needs of the present generation, with provision of such possibilities for future generations. Sustainable development should meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

The pattern of water resources engineering development in a context of sustainable development consists in the concept that the development of society along all directions (social, economic) can be realized only under conditions, regulated by natural parameters of water usage, i.e. in tight association of the water users with requirements of WR protection and self-regulation of aqueous ecosystems. Today it is recognized that threat to human survival as biological species is largely determined by the availability of WR, their condition and prevention of their degradation under technogenic and anthropogenic loads. In other words, the water management policy should be based on the ecological imperative - priority in saving of natural resources as to formation and protection of WR.

Development of human community is impossible without impacts on natural WR. It is necessary to provide for allowable levels of impacts. These impacts can be differentiated on the following levels:

- impact on nature and WR in particular without a noticeable strain on the environment;
- contamination and clogging of water bodies;
- noticeable negative impact on natural terrain and aqueous ecosystems;
- degradation and destruction of a natural environment and WR in particular.