WATER AND PUBLIC HEALTH: A MULTIDSICIPLINARY ISSUE

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ВОДНЫЕ РЕСУРСЫ И ЗДРАВООХРАНЕНИЕ: МУЛЬТИЦИЦИПЛИНАРНЫЙ ВОПРОС

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The aim of this paper is to give an generell overview of water and health. Furthermore it enlightened which discipline are involved in serving good quality water to public and industry. However there are still a problems, especially in developing countries. A touch of the history of sanitation during from Roman Times over Middle Age to Modern Times gives an insight view what was achieved and what was lost. To manage all the problems with water and wastewater, a profound knowledge about the water itself, it occurrence in time and the required technology in drink water and wastewater treatment is necessary. Despite all these achievement, many people in developing countries suffer on water related diseases, especially in hot climate.

Keywords: Water Quality, Sanitation, Water-related Diseases, Hot Climate.

Цель этой статьи — дать общий обзор значения водных ресурсов для общественного здоровья. Поазана мультидисциплинарность подходов, которые необходимо применять для обеспечения качества воды для общественности и промышленности. Освещены проблемы, особенно актуальные в развивающихся странах. Исторический обзор мер санитарии и очистки воды со времен Римской эпохи и средневековья до настоящего дает представление о том, что было достигнуто и что было потеряно. Для решения всех проблем, связанных с водоснабжением и сточными водами, необходимы знания о самой природе воды, ее появлении, рециркуляции во времени и требуемых технологиях в питьевой воде и очистке сточных вод. Несмотря на все современные достижения в этой области, многие люди в развивающихся странах страдают от болезней, связанных с водой, особенно в жарком климате.

Ключевые слова: качество воды, санитария, заболевания, связанные с водой, климат.

Introduction

Water is the most important natural resource in the world. Without water life cannot exist and many industry relay on water. Furthermore there is no substitute for water, and it plays a major and vital role in development of communities. It will be used directly, either consumption by man or for daily service in sanitation. Furthermore it plays a major role in various industrial processes, and with the help hydro-electric barrages and dams it creates electrical energy. Pump-storage schemes [1] yield in an efficient way both energy and storage of energy. Unfortunately, liquid and solid wastes from such communities have a considerable potential for environmental pollution. Therefore water as a natural resource have to be carefully managed, as growing populations and industrial developments demand and even increase supplies of water.

Historical Background

Even in ancient civilization, the importance of water supply and sanitation provisions was well know. Archaeological investigation shows that latrines and drains where present in Neolithic dwelling. The Minoan civilization [2] in Crete 2000 years B.C. had clear water and flushing toilets in the houses. The Romans had highly developed water supply and drainage systems and their cities used large amounts of water. Huge buildings like aqueducts, e.g. Pont-du-Gard in southern France, pay still attention of the Romans water supply. These aqueducts provided communities with good-quality water. Surface water and discharge from latrines were removed in stone sewers out of the cities. But with the fall of the Roman Empire many of these systems and construction declined, and for centuries water supply and sanitation systems disappeared. Most of todays cities were build on rivers during the Middle Age, because these rivers provided the water needed, and also served for waste disposal. In larger towns sewers were build, but only for removal of surface water. By this time sanitary provisions were usually very meager. It was common to discharge liquid and solid waste from windows into the streets. Therefore it is not surprising that life expectancy was less than half of the todays figure in the developed world. To improve these circumstances,

large towns e.g. London passed a law in 1847 [3], too allow cesspit and latrine wastes to be discharge to the sewers. London's sewers drained into the Thames, from which much of the city's water was obtained. As the sewer system was not well maintained and in the best condition, a continuously leakage of waste water into the aquifer appeared. But water from aquifer was the second main water sources. The unavoidable consequences of this state of affairs, were that water sources became increasingly contaminated by sewage, waterborne diseases became uncontrollable in the city. The outbreak of cholera at the Broad Street Pump in 1854 caused 10.000 deaths. Dr. John Snow provided the information to demonstrate the link between sewage pollution of water and enteric diseases like cholera and typhoid.

The lost of 10.000 lives and public outcry, leads to the first public heath engineering works. Bazalgette, Joseph [4] was the chief engineer of London's metropolitan board, which was established in 1856. In the year 1866 nearly most of London was connected to a sewer network devised by Bazalgette. It can be stated that waterborne diseases was nearly under control in the UK by 1870. Corresponding developments were talking place in other major cities around the world. With the Industrial Revolution the demand of urban water increased, and construction of major water-supply schemes engaging huge upland impoundments were established too. Only the continual and careful attention of water quality control made it possible that waterborne diseases are almost eradicate in developed countries.

In the developing world the situation regarding water supply and sanitation are quiet different. During the last decades there was improvement in wastewater treatment and other facilities, but 2,4 billion people do not have access to improved sanitation facilities. Further more around 1 billion people worldwide still practice open defecation [5]. Estimation by UN 2017 figure out 842,000 deaths in middle- and low-income countries in the year 2012, which were caused by contaminated drinking water, inadequate hand-washing facilities, and inappropriate or inadequate sanitation services. Nevertheless, improved sanitation coverage does not necessarily equate with improved wastewater management or public safety. Only 26% of urban and 34% of rural sanitation and wastewater services effectively prevent human contact with excreta along the entire sanitation chain and can therefore be considered safely managed [5].

The Role of Scientists and Engineers

It can be stated, that water science and technology is an interdisciplinary issue involving application of biological, chemical and physical principles in connection with engineering topics. Civil Engineers have always been great activities in planning and building of water supply and sewer systems, and wastewater treatment plants. Public health engineering is probably one of the larges part of civil engineering profession. Together with scientific colleagues they have a profound association in reducing the incidence of various water-related diseases. The work and the responsibilities of engineer starts with development of water sources. The sources have to provide continuos comfortable supply of water of healthy quality and free from:

— visible suspended matter,
— excessive colour,
— taste and odour,
— objectionable dissolved matter,
— aggressive constituents,
— bacteria indicative of faecal pollution.

The water sources can be every kind of water like a natural lake, a river our groundwater. All these sources are play an important role within hydrological cycle. These cycle also include all water on earth. There is a huge amount of water present in the earth and its atmosphere. Around seven per cent of the earth's mass is made up of water. Nevertheless, 97 per cent of all water appears as saline water in oceans. Most of the remaining three per cent is freshwater, and trapped in the polar ice. Only 0.7 per cent of all earth's water occurs in lakes, rivers, aquifers and in the atmosphere. However, if the water were evenly distributed on the surface of the earth and if the world population were similarly distributed there would be no lack or shortage of water. Unfortunately the spatial distribution of rainfall is not even and crowded urban areas consume large amounts of water, consequently shortage of water occur. Hydrology, which is the science of management of the hydrological cycle and its water resources is another important part in the increasing demands of water throughout the developing world. It must therefore appreciated that in considerations of water resources it is essential to assess both the quality and quantity of the source. If the water source for a city or community fulfill all the above mentioned constrains, then the water must be delivered to the consumers via a complex distribution system. Depends on the quality of water, sometimes it must be treated with various technology. Industrial and domestic user of water usually produce deterioration in quality, therefore the wastewater must be collected and given effective treatment before release to the environment. Sometime treated wastewater plays significant part of the water resource and are available for reuse. Water reuse take place in a wide range of application, like agriculture or gray water. But these application needs further advanced monitoring and management.

Assessing the Quality of Water and Wastewater

All waters either natural or reused contain different proportion of various matters. Natural rain might have only a few milligrams per liter, whereas sea water contain up to 35000 mg/l. Wastewater contain dissolved constituents, which arise from the water sup-

ply and from other pollutants during waste-producing processes. The human metabolism releases about 6 g of chloride each day. Therefore domestic sewage contain around 40 mg/l by 150 liter per person and day. It can be stated, that the release of 40 mg/l chloride per person and day is more than the chloride from the water supply. Raw sewage contains more or less 1000 mg/l of solids in solution and suspension. The remaining 99,9 per cent is just water. Seawater at 35000mg/l of impurities is apparently much more contaminated than raw sewage. On the other hand the measurement of total solids do not say anything about the character of the water. For example a clear sparking groundwater can have for total solids than seawater [6]. For a true picture of the nature of a particular water, it is necessary to measure several different properties to assess the physical, chemical and biological characteristics. The characteristics are very different in its own. In the following paragraph a short description of nearly all parameters is given. For more detailed information the reader might refer to [7].

The Physical Properties do not need so sophisticated methods as chemical and biological issue. In many cases it is relatively easy to measure. Temperature is one of the basic information, it is important for chemical reaction and reduction in solubility of gases, etc. Depends on the environment of the water, the Colour is quiet different. Therefore water from upland catchment shows natural yellow colour, due organic acids. But even pur water is not colourness, it is pale green-blue tint in large quantities. For consumption it should be clear and aesthetically. Turbidity occur when colloidal solids present in water is not so aesthetically, but may be harmful. Turbidity in water might come from clay and silt particles, sewage discharge to industrial wastes, or it might indicate large numbers of microorganisms. Solids.These may be present in suspension and/or in solution and they can be divided into organic matter and inorganic matter. Total dissolved solids (TDS) are due to soluble materials whereas suspended solids (SS) are discrete particles which can be measured by filtering a sample through a fine paper. The Electrical Conductivity depends on the quantity of dissolved salts present and for dilute solutions it is approximately proportional to the Total dissolved solids (TDS). The measurements of gross beta and gamma Radioactivity are routine quality checks. Radon is a naturally occurring radioactive gas, which relay on the particular soils and rocks. Therefore it can be a possible long-term health hazard with some groundwaters.

The Chemical Characteristics or parameters are more useful in assessing the properties of a sample, because there are more specific in nature than physical parameters. Also there are quiet more chemical parameter than physical one. The following description can only give an overview of the chemical characteristic. The reader might be find more detailed answer in [7].

A water sample can be acid or alkaline, the intensity of such sample is measured on the pH scale. The value of pH indicates the concentration of hydrogen ions.

The Oxidation-reduction potential (ORP) measures the capacity of a solution to either release or accept electrons from chemical reactions. The ORP value, much like pH, is important for determining water quality and for water treatment processes.

Alkalinity is the capacity of water to resist changes in pH that would make the water more acidic. Alkalinity is useful in waters and wastes in that it provides buffering to resist changes in pH. It is normally divided into caustic alkalinity above pH 8.2 and total alkalinity above pH 4.5.

Acidity is determined by measuring how much standard base must be added to raise the pH to a specified value. Acidity is a net effect of the presence of several constituents, including dissolved carbon dioxide, dissolved multivalent metal ions, strong mineral acids such as sulfuric, nitric, and hydrochloric acids, and weak organic acids such as acetic acid. Dissolved carbon dioxide is the main source of acidity in unpolluted waters.

Calcium and magnesium dissolved in water are the two most common minerals that creates the Hardness of water. The degree of hardness becomes greater as the calcium and magnesium content increases and is related to the concentration of multivalent cations dissolved in the water.

Dissolved oxygen (DO) is necessary to many forms of life including fish, invertebrates, bacteria and plants. These organisms use oxygen in respiration, similar to organisms on land. Fish and crustaceans obtain oxygen for respiration through their gills, while plant life and phytoplankton require dissolved oxygen for respiration when there is no light for photosynthesis. The amount of dissolved oxygen needed varies from creature to creature.

Biological Oxygen Demand (BOD), is a measurement of the amount of dissolved oxygen (DO) that is used by aerobic microorganisms when decomposing organic matter in water. Biochemical Oxygen Demand is an important water quality parameter because it provides an index to assess the effect discharged wastewater will have on the receiving environment. BOD is also used extensively for wastewater treatment, as decomposition of organic waste by microorganisms is commonly used for treatment. Regulations for BOD will vary by country and region. In general, maximum allowable concentration for direct environmental wastewater discharge fall around 10 mg/l BOD and maximum allowable concentrations for discharge to sewer systems around 300 mg/l BOD.

Nitrogen is essential for all living things as it is a component of protein. Nitrogen exists in the environment in many forms and changes forms as it moves through the nitrogen cycle. However, excessive concentrations of nitrate-nitrogen or nitrite-nitrogen in drinking water can be hazardous to health, especially for infants and pregnant women.

Chlorides are salts of hydrochloric acid or metals combined directly with chlorine. They are responsible for

brackish taste in water and are an indicator of sewage pollution because of the chloride content of urine. The threshold level for chloride taste is 250-500mg/1, although up to 1500mg/1 is unlikely to be harmful to healthy consumers who are accustomed to that concentration.

Organic compounds [8] are mostly from human activity or industrial operations. Substances which have been found include benzene, chlorophenols, oestrogens, pesticides, polynuclear aromatic hydrocarbons (PAH) and trihalomethanes (THM). They are normally present in very low concentrations, but there is some concern about possible health effects if such materials were consumed over a long time even at trace levels. When dealing with industrial wastewater or their effects on watercourses and aquatic life many other specialized chemical characteristics may be important, including heavy metals, cyanide, oils and greases.

The Biological Characteristics of water and its assessment is a topic of its own of great significance. There are living microorganisms in natural water, which play major roles in the aspects of water quality control. Many bacteria, viruses and protozoa are causative organisms for some of the more virulent diseases transmitted to humans directly through water. Assessment and confirmation of the presence of the causative agent of waterborne diseases are very tedious and time consuming. Coliform organisms have been used to determine the biological characteristics of natural waters. The coliform group of bacteria are aerobic and/or facultative gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose to gas. Escherichia coli is commonly used as an indicator organism. This organism is present in the intestine of warm-blooded animals, including humans. Therefore the presence of Escherichia coli in water samples indicates the presence of fecal matter and then the possible presence of pathogenic organisms of human origin. Raw sewage contains millions of bacteria per milliliter and many organic wastewater have large populations of bacteria, but the actual numbers are rarely determined. Conventional treatment methods for sewage and organic wastewater rely on the ability of microorganisms to stabilize organic matter so that very large numbers of microorganisms are found in wastewater treatment plants and in their effluents. Microorganisms can thus play valuable roles in wastewater treatment and sometimes also in water treatment, but they are usually considered as sources of potential nuisance and hazard in relation to drinking water.

Water Quality and Health

As mentioned above that water is essential for human life and development, it also can, if contaminated, great potential for transmitting various diseases and illness. Due too the water supply and wastewater disposal systems in the developed world, water related diseases are very seldom or rare. However, in the developed world, there is concern about the possible long-term health hazards that may arise from the presence of trace concentrations of impurities in drinking water, with particular attention being paid to potentially carcinogenic compounds. There are several other chemical contaminants, which may be naturally occurring or man-made, that have known effects on the health of consumers. It is therefore important that the relationships between water quality and health be fully appreciated by the engineers and scientists concerned with water quality control. In 2002 approximately 1.3 billion people are without proper water supply and almost 2.6 billion do not have adequate sanitation facilities, which 42 per cent of the world's population. As a result, the figure of water-related disease in these areas is frightening in its extent. Millions of people die each year as the consequence of unsafe water or inadequate sanitation and although exact information is difficult to obtain. Every diseases require for their spread a source of infection, a transmission route, and the exposure of a susceptible living organism. Control of disease is thus based on curing sufferers, breaking the transmission route and protecting the susceptible population. Therefore diseases control can be measured in different ways either via engineering by breaking the transmission route and by medical measurement. Bradley in [9] described about two dozen infectious diseases, which are driven by water. These diseases may be due to viruses, bacteria, protozoa or worms and although their control and detection is based in part on the nature of the causative agent it is often more helpful to consider the water-related aspects of the spread of infection.

There are different ways of infection with Water-related diseases:

— Waterborne diseases,
— Water-washed diseases,
— Water-based diseases,
— Water-related insect vectors.

Waterborne diseases are spread by contamination of water by human faces or urine, and it is the commonest from of these diseases. The infection occurs when pathogenic organism gains access to water which is then consumed by a person who does not have immunity to the diseases. Contaminated water can cause many types of diarrheal diseases like cholera, typhoid, bacillary dysentery, etc. It is estimated that these diseases cause 4 million deaths each year. It should be mentioned that although these diseases can be waterborne they can also be spread by any other route which permits direct ingestion of faecal matter from a person suffering from that disease. Poor personal hygiene of workers in food handling and preparation would provide an obvious infection route. Poor personal hygiene of workers in food handling and preparation would provide an obvious infection route. The situation is further complicated in that some people may be carriers of diseases like typhoid so that although they exhibit no outward signs of the disease their excreta contain the pathogens. Weil's disease (leptospirosis) is trans-

mitted in the urine of infected rats and the causative organism is able to penetrate the skin so that external contact with contaminated sewage or flood water can spread the disease. Workers in sewage systems have to be screened constantly.

Water-washed diseases are infections that are caused by poor personal hygiene resulting from inadequate water availability.These malady may be prevented if people have acceptable supplies of drinking water for hygiene. These include a number of skin and eye infections which, whilst not normally fatal, have a serious debilitating effect on sufferers. The diseases of this type include bacterial ulcers and scabies, and trachoma. Scabies is easily transferred through person-to-person contact and some 300 million people contract the disease each year. Trachoma is a bacterial eye infection that begins as conjunctivitis, but if left untreated can cause blindness. Trachoma spreads through direct contact and is most common in communities without proper sanitation facilities. More than six million people worldwide may be blind because of this disease, and some 150 million more await treatment. All these diseases tend to be associated with hot dry climates and their incidence can be significantly reduced if plenty of water is available for personal washing.

Water-based diseases are caused by aquatic organisms that spend part of their life cycle in the water and another part as parasite of animals. These diseases are caused by worms which infest the sufferer and produce eggs which are discharged in faeces or urine. Infection often occurs by penetration of the skin rather than by consumption of the water. Schistosomiasis (also called bilharzia) is probably the most important example of this class of disease. The transmission way of schistosomiasis is quiet complex. If a sufferer excretes into water, eggs from the worms hatch into larvae which can live for only 24 h unless they find a particular species of snail which acts as an intermediate host. The larvae then develop in a cyst in the snail's liver which, after about six weeks, bursts and releases minute free-swimming cercariae which can live in water for about 48 h. The cercariae is able to puncture the skin of humans and other animals and they can then migrate through the body via skin, veins, lungs, arteries and liver in a period of around eight weeks. The parasite then develops in the veins of the wall of the bladder, or of the intestine, into a worm which may live several years and which will discharge enormous numbers of eggs. Schistosomiasis is often spread by irrigation schemes and stagnant water behind dams. Therefore it tend to provide suitable environment for the snail host as well as increasing the likelihood of contact with the water by agricultural workers.

Another water-based disease which is widespread in the tropics is Dracunculiasis (guinea worm). The intermediate host is cyclops, which is a small crustacean. The infection occurs by ingestion of water containing infected cyclops. The eggs are discharged when an ulcer on the skin of a sufferer bursts and they can remain viable in water for one or two weeks. If eggs are ingested by cyclops they develop into larval forms in a further two weeks. The larvae leave the ingested cyclops during human digestive processes and migrate through the tissues to the lower limbs of the body and eggs are discharged about nine months later. The vector species of cyclops is prevalent in stagnant water with some organic content. Control of guinea worm, which can bring marked improvements in the health of the population, is essentially based on protection of water sources, particularly springs and wells. The provision of sloping hardstandings and small walls round water sources will effectively prevent the access of eggs to the water.

Water-related insect vectors which means, there are insects which breed or feed near water so that their occurrence can be related to the closeness of suitable water sources. The infection of such diseases is in no way related with human consumption of water,or contact with water. Insects like mosquitoes, which transmit malaria and many other diseases, prefer shallow stagnant water in pools, around the edges of lakes and in water storage jars. It is therefore important to ensure that water supply and drainage works do not provide suitable mosquito habitats. Unfortunately these are not always possible. Therefore, mosquitoes should be prevented from gaining access by the provision of effective screens. Simulium flies, which transmit onchocerciasis (river blindness), breed in turbulent waters associated with rapids, waterfalls, etc., or created by engineering structures like weirs, energy dissipators, etc. Control is usually by use of insecticides injected upstream of the point of turbulence. All these water-related diseases are most common in developing countries with hot climate and inadequate water supply and sanitation, and enormous hazards to public health in large areas in the world.

However, there are also water-related diseases in the developed world. For example the outbreaks of Legionnaires' disease, which has a strong have strong evidence to the presence of Legionella pneumophila in domestic hot water supplies, shower heads, cooling waters and other aquatic systems which produce droplets or fine sprays. As a result of the solvent properties of water many substances may be found in solution in natural waters and some of them are potentially hazardous to human life. In most cases the concentrations of most potentially harmful impurities in natural waters are normally very low but there are thousands of compounds used in agriculture, in the home and in industry which can find their way into surface. The description of all these chemical compounds, from source, occurrence, chemical reaction to other parameters, and the treatment in water supply and wastewater treatment are tremendous and a chapter of its own and out side the scope of this paper.

Conclusion

Providing the public and the industry with adequate water is a business of its own in the developed world. Many processes and different subjects are involved, until the water flow to the tap of the public and of the industry. Hydrologists are involved by finding competent sources of water, either surface or groundwater, civil engineer design, plan, and work on the distribution of the water system, and the wastewater collection system including the treatment plant. Staff in the laboratories monitoring constantly the quality of drinking water. Chemists, Biologists and Medical Doctors define standards of water quality and its threshold levels. In addition to these management and monitoring of water and wastewater special devices and procedures are developed by water authorities and private companies. For example, laboratory equipment and special hard and software for analyzing has been developed. All these work well in the developed world. But, by facing the water and health problems in the developing world, an another approach is necessary. Good quality technics in water supply like hard surface with a mild slop around a water pump is very helpful in avoiding contamination of drinking water. Furthermore robust and proper wastewater collection system should prevent for infection. With the help of engineer solution stagnant water, which provide condition for unpleasant breeding of mosquitos can be avoided. It can be stated, a lot of water related diseases can be controlled via the transmission route water. Furthermore education and teaching should go hand in hand.

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