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REDUCING HARMFUL EFFECTS OF METALS IN WATER

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Nowadays, drinking water has become an increasingly critical and complex issue of mankind. Consumption of low-quality water contaminated with heavy metals has detrimental effect on human health, leading to disastrous consequences for human population. This paper is focused on the problem of adverse impacts and effects of contaminated drinking water and heavy metals it contains, as well as on strategic planning and efficient elimination of the above problems and consequences of such contaminated water on human health. Values of water before and after the purification process are presented. An effective solution has also been elaborated and proposed in the form of an existing commercial device for purifying and restoring water to its natural state with a balanced chemical composition and natural properties.

Key words: water, heavy metals, human health, sanitary aspects

INTRODUCTION

Water is one of basic factors required for the survival of all living organisms on Earth, including humans. When used as a food product, water should have natural elements and its chemical composition and properties also need to be as in the nature.

The continuous advancement of civilization, the development of industry and uninterrupted appropriation of uninhabited areas all have led to the successive increase both in the number of pollutants and the number of polluted natural resources. As a result of human activities and various forms of industries, the natural balance of elements, their chemical composition and relationship are changed, leading to water pollution. Nowadays, water pollution comes from the transportation industry (most directly by water transportation), the excessive use of fertilizers and pesticides, as well as solvents and detergents in households and factories, and metals from industrial processes (Pb and Hg).

Each of these pollutants finds its way to rivers through which its proceeds to the sea, but also groundwater and drinking water wells.

Water can be polluted by harmful substances in both direct and indirect way.

Direct forms of pollution include establishment of separate wastewaters into which harmful substances are conveyed, which are then typically discharged directly into river flows. Harmful substances coming from industrial plants are industrial wastewaters, while those coming from households and urban areas are municipal wastewaters. Both are carrying huge amounts of harmful substances, which eventually end up in water, and thus, in all living organisms, including human body.

Water is indirectly polluted by the runoff process of harmful chemicals into the soil. On their way they reach ground waters, where the process of natural circulation drives them to pollute rivers, lakes, seas.

HEAVY METALS IN WATER

The removal and safe disposal of heavy metals (Figure 1) both from industrial wastewaters and from the water intended for human consumption is one of the major environmental problems of modern world.

Current methods of removing heavy metals from wastewaters include precipitation, adsorption and biosorption, electrolytic extraction, membrane separation, solvent extraction and ion exchange [1].

Wastewaters produced by various industries are contaminated by various chemical agents (heavy metals and organic pollutants).

There are a number of different processes for treating wastewaters, starting from traditional methods such as the lime-based chemical precipitation or redox processes, coagulation and flotation, through the efficient

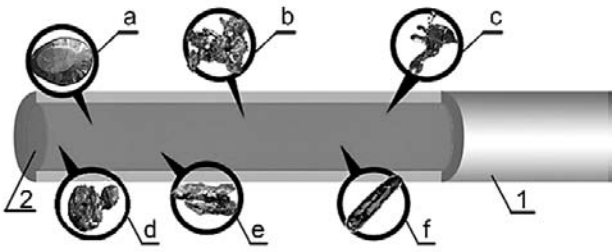

Figure 1 Heavy metals in drinking water: 1 – pipeline, 2 – water, a – Pb, b – Cu, c – Hg, d – Fe, e – As and f – Cd

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but very costly methods such as ion exchange, reverse osmosis, electro-dialysis, ultra-filtration, electrolysis, etc. The use of these methods is limited due to the high costs and large amount of secondary waste they produce (e.g. sludge after the precipitation).

The most commonly used process of removing heavy metals from water is precipitation in the form of insoluble hydroxides in a weakly alkaline solution [2].

The main problem with this method is related to the disposal of the secluded hydroxide. Also very effective technology for removing heavy metals from wastewaters is their treatment by active carbon. However, the use of active carbon is limited by its high costs and high loss during the regeneration process.

Table 1 shows the permissive values of heavy metals in drinking water.

Table 1 **The expected values for drinkig water**

Heavy metals	Amount / mg/l
Pb	0,05
As	0,05
Cu	1,00
Fe	0,30

REMOVAL OF ORGANIC SUBSTANCES

The presence of organic substances in large quantities is generally indicated by the noticeable discoloration of water. In deep wells these substances are usually humus materials, while in surface waters and shallow wells presence of organic substances indicates the possibility of fecal contamination. For removing organic substances from water there are devices using special fillings to remove organic matter (scavengers). When the filling reaches the point of saturation, it is regenerated using a mixture of salt and caustic soda.

DENITRATION

Except for an extremely harmful effect on human health, the nitrate concentration in excess of the permissible limits is often a sign of water pollution by organic substances that may be of fecal origin. There are nitrate-removing devices in production that work based on specific ion-selective ion-exchange masses which convert the nitrate ions to harmless chloride ions. After saturation, denitrators are periodically regenerated using sodium chloride solution.

DECHLORINATION AND REMOVAL OF HEAVY METALS FROM WATER

In order to maintain the microbiological quality of drinking water, prior to its distribution to the water supply system water is chlorinated using certain excess chlorine (residual chlorine) in order to maintain its subsequent infertility. It is this excess chlorine which can have a very unpleasant effect on the organoleptic properties of drinking water (taste and odor), while in contact with organic substances it can build compounds that are very dangerous to people (some of which are even carcinogenic). Nowadays, water is dechlorinated only by using water filters with active carbon.

Deodorization means repairing the quality of water, i.e. removing substances that can induce bad taste, odor, and in some cases colour. Therefore, filters based on active-carbon are used, since it is a very strong adsorbent binding for these substances. Upon the exhaustion of its adsorption capacity, the active carbon is replaced. These filters are mostly used for dechlorinating and deodorizing drinking water, as well as in food technologies that use tap water [3].

WATER FILTRATION

Water filtration is a basic operation aiming to remove all mechanical particles dispersed in water. The method of filtration is selected based on the type and size of dispersed particles. Generally, various filter housings are used with appropriate filter cartridges of various porosities, and there is a whole range of semi-automatic and automatic filters in use that can be rinsed during operation, so that there is no discontinuity in operation for replacing or cleaning the filter cartridges. Highly contaminated waters may be filtered using traditional sand filters with multilayer silica fillings of various granulations.

REMOVING Fe AND Mn FROM WATER

In many cases of water with high content of Fe, it is necessary to minimize its amount. High Fe content results in very unpleasant taste of drinking water and also produces brown precipitate of ferric hydroxide (Figure 2), which can lead to severe microbiological problems in pipelines. In many manufacturing processes, particularly in the textile, paper and food industries, the Fe content should also be kept to a minimum level.

Figure 2 High Fe and Mn content water

DETRIMENTAL IMPACT OF LOW QUALITY WATER ON HUMAN HEALTH

According to the norms of International Sports Medicine Institute, the daily requirement of water for less physically active people is 30 cm^3 for every kg of body weight (10 glasses of water per day for a body weight of about 80 kg), while for athletes it is 40 cm^3 (13 to 14 glasses per day for a body weight of about 80 kg).

The presence of high concentration of ions that can form weakly soluble compounds in water can lead to the formation of deposits or stones (kidney stones) [4].

Table 2 provides the intake of elements in the human body with the consumption of drinking water. These data have been calculated based on the 0,2 dm^3 glass volume and assuming that the daily water intake amounts 10 glasses, i.e. 0,2 dm^3. The calculation is based on the content of the corresponding element calculated based on the dry residue. The monthly and annual intakes are based on 30 days and 12 months (365 days), respectively [5].

Table 2 **Intake of the elements in human body calculated based on the consumption of drinking water**

Elements	Intake glass of water /mg	Annual intake /gr
Mn	0,806	2,90
Fe	0,77	2,76
Co	0,06	0,23
Ni	0,07	0,26
Cu	0,43	1,55
Zn	0,07	0,26
Cd	0,104	0,37
Hg	0,114	0,51
Al	0,02	79,20
Si	0,16	0,58
As	0,02	82,37
Pb	0,62	2,25
Σ	2,686	196,01

THE USE OF COMMERCIAL WATER TREATMENT EQUIPMENT

Deferisation devices consist of a column filled with special catalyst filter mass which catalyzes Fe from its soluble to insoluble form and precipitates it on itself. The precipitated Fe is periodically removed from the device by simply countercurrent washing; this results in low operating costs along with high efficiency.

Reverse osmosis (RO) is a very simple water filtering process. Since the late 1950's, using the RO process, under high pressure (using a pump) saline or seawater has been converted into drinking water. Today, RO is the best and most convenient water filtering method. This advanced technology is now widely available and used for filtering water in both homes and offices, contributing to a healthy lifestyle.

Reverse osmosis is based on a semi permeable membrane with tiny holes which allows only pure water molecules to pass through it, discarding all the pollutants that are overly large. The smallest known bacteria and virus are 0,2 μm and 0,002 μm wide, respectively, while the diameter of the semi permeable membrane hole is 0,0005 μm. As clearly indicated by this comparison, neither viruses nor bacteria can pass through the membrane hole. When water and the impurities contained reach the osmotic membrane, their flow is separated in two directions: a penetrating flow which passes through the membrane holes (purified water) and a concentrated flow that leaves through the outlet along with the retained impurities in the form of technical waste water (Figure 3) [6].

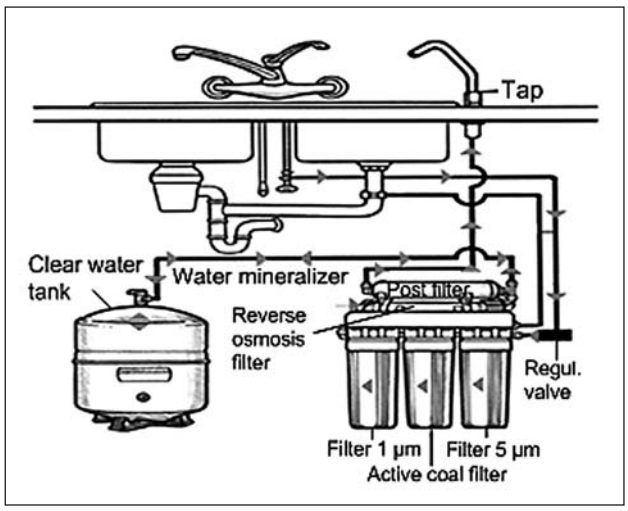

Figure 3 A device for purifying domestic water

CONCLUSIONS

All organisms need water to survive and it is the most important fluid of which their physical and chemical processes depend. Water is the means of dissolving and transporting substances throughout the body. It enables the process of digestion and absorption of nutrients and oxygen, as well as purging metabolic products. In cells, water maintains necessary pressure. In organisms that have the ability of thermoregulation it facilitates natural cooling of the body by sweating.

The rapid development and progress have led to significant reduction and pollution of water resources. This is the reason why nowadays the world is faced with the highest water supply crisis ever recorded. According to the World Health Organization, the situation is rather worrying when it comes to reserves of both pure water (either running or standing) and groundwater used for drinking.

As forecasted by the United Nations, seven billion people will face water shortages by the mid of the 21st century [7].

Using the existing commercial devices of the leading manufacturers (Figure 3), water can be purified and thus, the quality of human life improved. Consuming high quality water, many diseases can be prevented,

such as osteoporosis, allergies and asthma, diabetes, hemorrhoids, high blood pressure and cholesterol, gallstones, heart disease, arthritis, kidney and bladder diseases and many others.

Water is the most abundant component of the human body. All body cells are soaked with water. It makes 70 ÷ 75 % of the total body weight and therefore an investment in the quality of the water we consume on daily basis is also a long-term investment in better health of every individual and population in general.

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Note: The responsible translator for English language is J. Šafranj, Faculty of Technical Science, Novi Sad, Serbia