Moroccan Journal of Chemistry
ISSN: 2351-812X
http://revues.imist.ma/?journal=morjchem&page=login
Alaqarbeh & al. / Mor. J. Chem. 10 N°4 (2022) 891-900
DOI: https://doi.org/10.48317/IMIST.PRSM/morjchem-v10i4.34497

Water pollutions: sources and human health impact. A mini-review

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Received 15 Jun 2022,
Revised 03 Sept 2022,
Accepted 05 Sept 2022.

Abstract

Water plays a vital role in human life and civilization development, but the development and human multiplicity activities led to water pollution. Various factors cause water pollution like environmental and climate changes, agricultural activities, geological changes, civilization, domestic, and industrial processes. These activities release different types of chemical and biological pollutants with different concentrations. Last decades, the quantity and quality of water are declining at horrible rate due to uncontrolled population growth, growing urbanization, expanding industrialization and increasing non-standard agriculture activities, near the drought that is affecting several countries in the different continents. While most developed countries have installed advanced technologies to treat wastewater, developing countries still suffer from water supply because of the high cost of water treatment or desalination facilities. International organizations such as EPA (U.S. Environmental Protection Agency) and WHO (World Health Organization) develop standards for controlling water quality in terms of chemical and biological concentrations to preserve human health and protect biodiversity.

Keywords: *Chemical pollutants, Pathogens, Heavy metals; COD; BOD.*

1. Introduction

The earth system consists of air, soil, and water. Water constitutes 70.8% of the components of the earth, while 29.2% are soil or solid ground. The water bodies are divided into two distinct types, saline water and salt water as oceans and seas. Most of the water in oceans and seas is not potable due to its extreme salinity; In addition, extreme salinity also makes desalinating the water more difficult and expensive [1]. Less than 1% of the remaining 3% of water is consumed for agriculture, drinking and industrial purposes [2]. Water supports all living beings on Earth [3-5], however, the quantity and quality of potable water are declining at an alarming rate due to uncontrolled population growth, growing urbanization, expanding industrialization and increasing non-standard agriculture activities [3]. The other type is freshwater or surfaces water such as ice sheets, icebergs, bogs, lakes, rivers, streams, and underground water [6]. Water defines as a substance consisting of hydrogen and oxygen elements, that exist in gaseous, liquid, and solid states. A tasteless and odorless liquid at room temperature, it has an important ability to dissolve many other substances. In fact, the versatility of water as a solvent is essential for living organisms [6]. It plays many vital roles in living activities, such as daily human use, industrial processes, recreational activities, transportation, electrical production, nuclear processes, and a biochemical medium for different living cells [7, 8]. Indeed, there are several standards that adjust water qualities such as pH, odor, color, minerals, dissolved ions concentration, and organic substances [6, 9]. These standards were discovered through scientific analyzes and adopted by the World Health Organization (WHO), and Environmental Protection Agency (EPA) [6]. The efforts of organizations are converged to develop international scientific norms for water quality; to ensure the protection of the food chains, and the other living organisms that affect human life. The guidelines for water quality control include three main parts, aquatic life, human health, and organoleptic [10-12]. In this article, water pollutants and their sources will be presented.

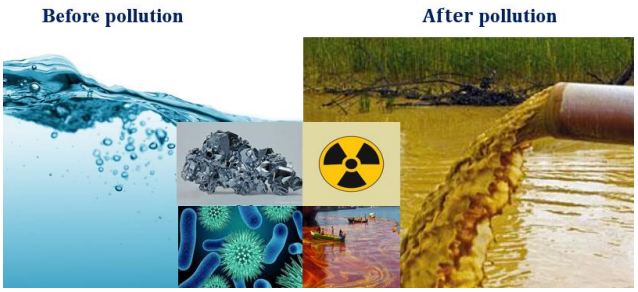

Photo : Water Pollution

2. Organic Pollutants

According to EPA and WHO, organic pollutants are classified into:

2.1. Oxygen-Demanding Wastes or Chemical Oxygen Demanding

Chemical Oxygen Demanding (COD), the measure of the capacity of water to consume oxygen during the decomposition of organic matter in the water, often used as a measurement of pollutants in water, wastewater, and aqueous hazardous wastes [13]. These are the wastes that undergo microbial degradation such as domestic sewage, food processing industries wastewater, canning industries, slaughterhouses, paper mills, tanneries, and breweries [14-16].

2.2. Synthetic Organic Waste

The synthetic organic waste called Persistent Organic Pollutants (POPs) resists microbial degradation contrary to COD. POPs are lipophilic toxins that have high degrees of halogens and high bioaccumulation in living tissues. POPs

are synthetic pesticides, synthetic detergents, food additives, pharmaceuticals, insecticides, paints, synthetic fibers, volatile organic compounds (VOCs), and plastics [17-20].

2.3. Oil

Oil is a naturally occurring organic liquid, produced by geological processes under special conditions for dead organisms buried under sedimentary rocks. Oil consists of a mixture of aliphatic and aromatic hydrocarbons, such as Poly Aromatic Hydrocarbons (PAHs), terpenes, gammacerane, and steranes [21-23].

2.4. Heavy metals

The exploitation of mineral resources provides human beings with a large amount of resources and energy, and also causes heavy metal pollution in water [24-26]. Heavy metals such as lead, iron, mercury, cadmium, zinc, arsenic, copper, and chromium, have the property of environmental persistence and bioaccumulation, and these heavy metals enter the aquatic system through various routes. These heavy metals not only impair the quality of the aquatic ecosystem but also human health [27-29].

3. Pathogens or Biological Pollutants

Pathogens are viruses, bacteria, and any microorganisms that cause possible severe diseases, such as cholera, typhoid, and hepatitis. They contaminate different water bodies through the discharge of urban sewage activates water bodies [30-32]. Bioplastic with palm oil has a yellow and transparent color compared to bioplastic without palm oil [33]. Bioplastic with a 1.90%(v/v) palm oil amount has a more homogeneous surface. Palm oil helped the gelatinization process and acted as a plasticizer [33].

4. Agriculture Pollutants

Agriculture pollutants are the most dangerous environmental pollutants because of their solubility in water, their spread through all earth components, and ease of leakage to the various water sources without control [34, 35]. Agriculture pollutants are classified into two classes, the first kind is abiotic ecosystem pollutants, as the chemical composition of fertilizer, pesticide, fungicide, herbicide, and sewage consisting of nitrogen and phosphorous. The second kind is biotic such as fungi feeding on N-compounds and P-compounds [10]. According to the Food and Agriculture Organization of the United Nations (FAO) report, nitrate of agricultural origin is the most common chemical pollutant in the world's groundwater aquifers; its contamination influences the quality of drinking water resources, with adverse effects on ecological and human health [36].

5. Thermal Pollution

Thermal pollution is a sudden water temperature change by discharging large quantities of hot water into water bodies. That is used for thermal power coolants, nuclear power coolants, or industrial coolants [37]. The risk of thermal pollution arises due to a significant change in water temperature, which affects the enzymatic activities, and metabolic rates, and reduces the oxygen level of the water. Thermal pollution also has an ability to intensify the consequences resulting from the chemical pollution [37, 38].

6. Solids, Sediments and Soil Sediments

It is a deposit of colloid and silt suspension in water bodies, by runoff rainwater over solid land surfaces of clay and sand. Creates ecosystem problems because they have a small surface area carrying and adsorb chemical and (or)

biological contaminants dissolved in water [39, 40]. They reduce the oxygen level in water necessary for aquatic life, and they perturb sunlight inside the water bodies. This leads to growing anaerobic organisms in the ecosystem as biological pollutants [35, 39, 41].

7. Inorganic Pollutants (Salts and Metals Ions)

These toxins are incorporating mineral acids, metal ions, metal oxides adsorb on soil sediments, dissolved metal oxide anions, complexes of metal ions with organic compounds, cyanides, SOx, NOx, halogen ions, and alkalinity (pH) of water [6, 35, 42, 43]. The main sources of water metal ions pollutions are industries and scientific research activities [44, 45]. EPA has been approving the Maximum Contaminant Level (MCL) of toxic metal ions as Al, Cd, As, Cr, Pb, Cu, Mn, Co, Ni, Zn, and Hg [10, 46, 47]. They are considering severe toxic pollutants for human health and constitute a general medical issue as mentioned in (Table 1).

Table 1: MCL for metal ions pollutants according to EPA criteria, [1].

Pollutant	MCL (ppm)	Health effect/(s)	Reference /(s)
Arsenic	0.010	Skin damage, problems with circulatory systems, and a high risk of getting cancer.	[47-49]
Mercury	0.005	Kidney, liver, and lung damage Neurotoxin.	[47, 50, 51]
Copper	1.300	Short-term exposure: Gastrointestinal distress. Long-term exposure: Liver, kidney damage, and cause Wilson's Disease.	[47,49, 50]
Chromium	0.100	Allergic dermatitis.	[47, 48, 50, 52, 53]
Lead	0.015	Infants and children: Delays in physical, and mental development Adults: Kidney problems; high blood pressure.	[47, 50, 54]
Aluminum	0.200	May develop Alzheimer's disease.	[47, 55]
Cadmium	0.005	Kidney, and liver damage Neurotoxin.	[47, 50, 56]
Manganese	0.050	Insomnia, weakness of muscle, with long-term exposure may lead to a nervous system problem.	[30, 54]
Nickle	0.006	Metabolic disorder.	[47, 50, 57]
Silver	0.100	Skin discoloration (argyria).	[47, 50, 58]
Uranium	≥ 0.002	Increased risk of cancer, kidney, and lung damage, bone accumulation, and neurotoxin.	[47, 59]

8. Radioactive Pollutants

Radioactive pollution is the contamination of the ecosystem with radio action, as a result of increment levels of radioactive atoms or radiations [60]. Radiations are defined as the transmission or emission of energy as waves or particles through space or specific materials. There are different kinds of radiations each one specified by unique physical properties such as frequency (ν), wavelength (λ), velocity (c), and energy (E) [60]. The energy of radiation is classified into two kinds, non-ionizing radiation, that have not sufficient energy to ionize the atom or molecule such as visible ray, infra-red (IR) ray, and ultraviolet (UV) ray, and microwave. The other type is ionizing radiation, which has sufficient energy to ionize the atom or molecule such as alpha (α), beta (β), gamma, X-rays, and neutron [60].

8.1. Type of Ionizing Radiation

Alpha radiations (α): These are natural ionizing radioactive decay particles produced from an unstable nucleus emitting a particle with Z = 2, and A = 4, it is a helium nucleus [61]:

α decay of ^{235}U:

$$^{235}_{92}U \longrightarrow {}^{4}_{2}He + {}^{231}_{90}Th$$

Beta radiations (β): These are natural ionizing radioactive decay produced from an unstable nucleus that emits a particle that has the same mass as an electron. It has the same charge as an electron called (β^-) or electron ray, by the decay of the neutron inside the nucleus to give proton and electron (β^-) [61]. The second type of beta radiation is positron ray (β^+), which has the same mass as the electron, but its charge is positive. It is produced by decaying the proton inside the nucleus to give neutron, electron, and neutrono [61].

β^- or e^- decay:

$$n \longrightarrow p^+ + e^- + \nu_e$$

β^+ or e^+ decay:

$$p^+ \longrightarrow n + e^- + \nu_e$$

Gamma radiations (γ): These are natural ionizing radioactive rays produced by unstable nuclei emitting electromagnetic waves, and have the highest energy and the shortest wavelength, ranging from 10^{-10} m – 10^{-14} m of electromagnetic waves. It has high energy that can penetrate living tissue and produce serious cell damage. Thick metal materials such as lead capture gamma rays [62].

8.2. Source of Radiation Pollutant

The quality of drinking water is directly related to the public health, so its radioactive level has gradually attracted growing attention [63-65]. The levels of α and β radioactivity can basically reflect the overall levels of radioactivity in water, therefore can be used to monitor radioactive pollution [64, 66-68]. In this regard, international organizations have established guidelines for the gross α and β activity concentrations of radioactivity in natural drinking water [68,69]. The exploitation of minerals mines increases the risk of exposure to natural radionuclides by exposing them to the outer surface of the earth. The risk increases when these radionuclides are migrated into the bodies of water that have been used for drinking purposes [68]. The source of radioactivity pollution can be summarized as :

- The cosmic rays reach earth from outer space. The quantity of pollution by cosmic rays depends on the altitude and the geographical location [70, 71].
- Emission from radioactive materials of earth core and earth mantels, such as uranium, thorium, and potassium-40 [72,73].

- The mining industries of radioactive minerals [74].
- Nuclear energy production [75].
- Radioisotopes and nuclear scientific research [76].
- Military sources such as nuclear weapons and nuclear reactors [77].
- Nuclear medicine and nuclear medicine wastes [78].

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(2022); https://revues.imist.ma/index.php/morjchem