Chapter 2
Pollution in Aquatic Environs: Sources and Consequences

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2.1 Introduction

For the sustenance of life, water is essential either directly or indirectly as it plays an immense important role in all living and biogeochemical processes including solvents, temperature buffers, metabolites, and lubricants (Hanslmeier 2011). Water is however said to be contaminated if unguided, and anomalies of several anthropogenic practices have hindered some of the water quality criteria, making the water unsafe to use. All health and life risks can be caused by water pollution. Depending on your type and source of pollutants, the effects may vary. Some of the pollutants like heavy metals, dyes, and some other organic contaminants act as endocrine-disrupting substances and are carcinogenic having their source of origin from pharmaceuticals, cosmetics, and personal care product wastes. For ecologists and environmentalists, anthropogenic sources are the main cause for invasion of pollutants in water body via various means (Adeogun et al. 2016). Due to rapid population growth and increased speed of industrialization, there has in the last decades been a huge rise in freshwater demand (Ramakrishnaya et al. 2009). The excessive use of fertilizers and toxic practices in particular is endangering human health by most of agricultural growing behaviors (Okeke and Igboanua 2003; Bhat et al. 2017). A decline of water quality has arisen from anthropogenic development in various parts of the world due to widespread urbanization, agricultural operations,

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industrialization, and population expansion (Baig et al. 2009; Wang and Yang 2016). Therefore, poor water supplies have significantly limited water pollution regulation and increased water quality (Bu et al. 2010); hence to the experts, government, and other agencies, water pollution is a subject of concern. Protecting the integrity of the river water is therefore highly important owing to severe water pollution and global water shortages. Industrialization is a big catalyst for growth and urbanization in every community. Although industrialization has countless benefits, it has been described as a major environmental hazard, as it releases to our immediate environment, soil, air, and water numerous toxic chemicals, pollutants, solid waste, and different kinds of microbes. Water pollution is particularly interesting and has now become a global problem and is highly influenced by developing countries as a consequence of their promotion of growth (Inyinbor et al. 2016 and Rana et al. 2017). This occupies 98% of our drinking and is pointless to be consumed because of the high level of salt. Approximately 2% of the planet's water is fresh, while 1.6% is locked up in glaciers and polar ice caps. For aquifers and wells, an estimated 0.36% is contained deep. Therefore, in lakes and rivers, only about 0.036% of total water sources on the earth are available. Across 45 developing countries, the WHO/UNICEF reported that the bulk (76%) of households are primarily responsible for water collection (Harikishore and Lee 2012).

2.2 Global Scenario of Water Pollution

Waterborne diseases are the major cause of death around the world which are due to unclean drinking water (Clasen et al. 2007; WHO 2010). For the safety and longevity of infants and children, clean drinking water is essential (Anderson et al. 2002; Vidyasagar 2007). According to the estimates, the death rate is 1.8 million worldwide due to diarrhoea. As people with medical conditions like AIDS, diabetic are more prone to get severe infections imposed by waterborne pathogens (Kgalushi et al. 2004; Laurent 2005).The percentage of households using an unclean source of drinking water has decreased throughout the less developed world, but it is extremely unlikely that all households will have a safe source of drinking water in the nearby future (Mintz et al. 2001). It has been estimated that nearly 884 million people in 2010 worldwide used an enhanced drinking water supply and forecasted that 672 million people will continue to use the improved drinking water system in 2015 (UNICEF 2010). So it is important to understand what drives a household to treat its drinking water with an unclean source of water. Nearly about five million deaths are occurring per year due to illnesses caused by waterborne diseases because of lack accessibility to safe drinking water. Oceans are covering nearly about 70% of planet earth, as these vast water bodies are not even now considered to be safe because of oil spillage, dumping of pollutants, and so on and even though the beaches around the world often used to close for solid waste collection along the shoreline.

2.3 Sources of Water Pollution

There are two major sources of water pollution, i.e. point sources and nonpoint sources. Point effluents have a clear detectable source which includes pipe connected to a warehouse, truck oil spill, and chemical effluents. Point contamination causes include liquid effluent (both urban and industrial) and storm sewer runoff and mostly impact the area near it, whereas nonpoint sources of pollution are those that come from different points of origin and number of ways by which chemicals penetrate the soil or surface water and arrive from numerous non-identifiable sources into the ecosystem. Also the water pollutants are further categorized into organic and inorganic pollutants. Inorganic water pollutants have their source of origin from acid mine runoff; heavy metals from metallurgical operations; surface runoff; mining, cutting, and burning activities; ground filling; runoff from the agricultural fields of the fertilizers that include nitrates, phosphates, etc.; and industrial chemical wastes, while the organic pollutants include the food waste, pathogens, biological volatile compounds, and organohalides. Some of the major sources of water pollution are discussed in details.

2.3.1 Load of Heavy Metals

Heavy metals have the capability to accumulate in the body of an organism without undergoing any degradation in any metabolic process. The source of heavy metals in waters includes industrial wastes, municipal wastes, rocks, and soils (Brady et al. 1994). An exposure of the living organisms to the heavy metals alters the physiological reactions inside the body and overall leads to cognitive behavioural changes. The effect of toxicity depends on the various factors like sensitivity of an organism, accumulation rate, etc. (Das et al. 1997). Various metals are essential like zinc (Zn), copper (Cu), manganese (Mn), iron (Fe), and nickel (Ni) as they act as micronutrients in order to carry on the biochemical and physiological functions of the various organisms like microbes and plants. Among various inorganic pollutants, heavy metals are not used to go under degradation process in natural waters like rivers and lakes so easily, thus leading to the process of bioaccumulation in the food web and food chains of various ecosystems (Jain 1978). However, so far as the sources are concerned, it has been estimated that wild animals and plants do contain heavy metal concentrations due to pesticides, fertilizers, mining activities, coal-based power plants, tanneries, steel industries, cement industries, metal chelates, and waste effluents. Excessive use of heavy metal-based pesticides is causing serious threats to various fragile ecosystems, thus affecting the biodiversity (Ghosh and Vass 1997) and human life sustenance. Some of the heavy metals do not have a documented physiological function but have been proven to be lethal if they are found to be more than the allowed consumable limits which mainly include the chromium, cadmium, lead, etc. (Bruins et al. 2000). As the allowed consumable limits for the Cd is 0.01 mg/L, Pb is 0.10 mg/L, and for Cu, it is 0.050 mg/L (ISI 1982). According to Tsuji and Karagatzides (2001), heavy metals lead to various deadlier health ailments like congestion of nasal mucous membranes and pharynx; tumour and cancer; gastrointestinal, muscular, reproductive, neurological, and genetic malfunctions; and oedema of eyelids.

2.3.2 Urbanization

Paul and Meyer (2001) reported that the leading cause for the increased amounts of phosphorus in the urban catchments is urbanization. After every pollutant washout from industries, urban runoff, domestic discharges find their way to reach nearby waterbodies where the problem, of euthrophication and algal blooms arises.

2.3.3 Oxygen-Demanding Wastes and Nutrient Enrichment

Due to lack of efficient waste management handling, both the organic and inorganic wastes get piled up which ultimately are accumulated in nearby water bodies including surface waters and groundwaters and become a source of pathogens (Bhat et al. 2018a, b). As in developing nation, sewage is not being treated from primary to advanced tertiary treatment in order to remove Nitrogen and Phosphorus which both are the leading causes of nutrient enrichment in lakes, rivers and seas which ultimately results in algal blooms and death of fishes by oxygen depletion. Moreover both natural and anthropogenic sources add nutrients especially nitrogen and phosphorus to the surface waters, as natural sources add minimum concentration, while human activities are resulting in the addition of large quantities of nutrients especially N and P where the natural balance entirely got disrupted. Howarth et al. (1996) reported that the North Atlantic ocean which is surrounded by temperate-zone rivers where net anthropogenic N input is highly correlated with total N fluxes. Howarth et al. (1996) reported that net anthropogenic input of N in the oceans and with their watersheds are highly correlated as well as the nitrate fluxes and total nitrogen are directly associated with human population density (Howarth et al. 1996; Goolsby and Battaglin 2001). It is easy to track the point sources, while diffuse sources show more spatial and temporal variation which includes agricultural surface runoff from fields. Despite strong regulation of the point source supplies in reaction to the Clean Water Act, the major source of water pollution in the United States is now contaminants from nonpoint sources (Carpenter et al. 1998).

2.3.4 Industrial Wastes

As in the manufacturing process of various industries like paper and steel industries, huge quantity of water is used and carries various organic and inorganic chemicals like acids, alkanes, and dyes to the nearby waters in the effluents. Huge quantity of flouride is added to rivers and lakes from the discharge points of aluminium industries while steel industries release huge amounts of cyanide and Ammonia by fertilizer plants, thus all these chemical pollutants affect the physiological as well as biological properties of nearby waterbodies. Fertilizers and pesticides are used to increase the productivity of the fields, but these chemicals like DDT, aldrin, dieldrin, malathion, parathion, etc. are involved in the production of toxins in the environment. These chemicals do not undergo breakdown to simple compounds but remain for longer period of time among the living organisms and in the environment via the process of bioaccumulation and biodegradation.

2.3.4.1 Oil Spillage

Oil discharges from carriers carrying petrol, diesel, and their derivatives to the surface of the sea, by means of accident or leakage, pollute the seawater to a large extent. Offshore oil drilling frequently contributes to marine resource contamination. The waste oil extends across the surface of the water and creates a thin layer of water emulsion into the liquid.

2.3.4.2 Acid Rain Pollution

Various anthropogenic activities like thermal power plants emit lots of sulphur dioxide and nitrogen dioxide into the atmosphere which react with rain and lower the pH of the normal rain water below 5 that results in fallout of acidic rain which damages building structures and carbonate and bicarbonate balance of soil and hence ultimately affects the plants and other life forms of inland waters and marine ecosystems.

2.3.4.3 Radioactive Waste

The radioactive materials come from the nuclear power plants, nuclear atomic plants, radioactive sediment, and radioactive minerals' exploitation in the environment. These wastes pose serious threat to soil, water, and living organisms even if they are present in very small concentrations. The half-life of some hazardous radioactive elements like cesium-137 and strontium-90 is about 30 years while for plutonium-239 is about 24,000 years. Hence these radioactive elements will remain active for many generations to cause deadlier diseases like bone cancer, premature delivery, and other serious ailments to human beings.

2.4 Micro- and Macropollutants of Water

There are two types of chemical water pollutants which include macro- and micropollutants, a relatively small number of macro-polishing agents usually occurring to milligrams per liter that are nutrients such as nitrogen (Gruber and Galloway 2008) and phosphorus (Filippelli 2008) and other natural organic agents which are listed under macropollutant category (Jorgenson 2009), while micropollutants are another listed category including organic and inorganic trace compounds in the quantity of mg per liter. As per Larsen et al. (2007), the challenging task for the scientists and other experts is to classify and to detect the effects of those micropollutants which are being added except the classical common pollutants whose sources are known, although the design of sustainable thermotechnology continues to classify newer compounds which are being added to waters and other ecosystems. The primary biomass production goes on increasing due to high nutrient pollution load to inland and ultimately to marine ecosystems like seas and oceans which results in depletion of oxygen levels in the upper layers of lakes, rivers, and seas, and hence anoxic conditions result in release of toxic gases and other toxins which are harmful for beneficial microbes and native vegetation of waters (Lohse et al. 2009; Heisler et al. 2008), and also due to disproportionate irrigation, heavy load of salts are being added to inland waters, thus leading to enduring problems (Kaushal et al. 2005). As due to climate change, sea level rise and extreme use of chemical pollutants are the leading cause for deterioration of groundwater qualtity as reported by Post (2005) in the coastal waters of China and India. Micropollutants can be harmful even at minimal concentrations, and their structural diversity is difficult to assess which leads to short-term and long-term effects (Schwarzenbach et al. 2006). Cosgrove and Rijsberman (2000) have reported that the identified sources are very scanty for micropollutants as various kinds of industrial estates use huge quantity of good quality of water for the manufacturing processes and lead to flow out pollutant effluents into the nearby water bodies containing both known and unidentified micropollutants. Nearly about all the developing nations lack the treatment facilities at the end of industrial effluents to remove or achieve goal of allowed limits of EPA and in countries like India and China where outlets are being directly discharged without any secondary or tertiary treatment, thus micropollutants in the milligram per litre for urban wastewater, though remain as such and affects the whole equilibrium balance of all the aquatic and terrestrial habitats (Shao et al. 2006).

Agricultural sector is among the major source of trace pollutants in the form of residues which varies from the various concentrations of nanogram to microgram per litre but although allowed limit varies as per rules of different countries (Bockstaller et al. 2009, Eliopoulou and Papanikolaou 2007). According to Watson (2004), the naturally occurring micropollutants bear odour, taste and undergoes series of reaction and may form various toxicants while the dumping municipal waste sites, military operation sites, and estates contaminate quality of groundwater via the process of leaching are being added to waterbodies. As more than 100,000 chemicals are registered which are being released into the nearby water bodies without complying with standard and norms, thus urgent need to provide a representational image of the size and nature of different types of micropollutants from different sources in order to address this global problem of water pollution (Schwarzman and Wilson 2009). Without promises of completeness, we seek to provide a representational image of the size and nature of this global problem of water pollution by discussing a set of very different types of micropollutants from different sources. Schwarzenbach et al. (2003) reported that it is quite challenging task to determine the detrimental effects of heavy metals including mercury, lead, chromium, cadmium, etc. which needs broad interdisciplinary approach to assess the quantity of micropollutants in aquatic ecosystems. After introduction of these invasive chemicals to the environment undergoes series of reactions like adsorption, absorption, oxidation/reduction, complexation and precipitation/dissolution and ultimately determines fate of these inorganic or organic micropollutants. The solubility of metallic minerals and metals depends upon the oxygen concentration and pressure. Manganese and iron are abundant and fragile to the varying oxygen levels as they easily get adsorbed under low oxygen availability and become more toxic under reductive conditions (Roberts et al. 2010). These reactive and toxic compounds can be dissolved and finally precipitated by microbes, by use of stable isotopes along with the mass spectroscopic techniques new analytical window through which microbial processes can be tracked by signatures of metallic elements, such as iron and manganese concentrations can be traced inn (Teutsch et al. 2009). As per Plumlee et al. (2006), X-ray diffraction techniques can be employed for the molecular characterization and to determine concentrations of metal ions as adsorbed on surfaces of the minerals and finally the mobility of toxic ions in the ecosystems can be tracked (Manceau et al. 2002). Hence the mobility of toxicants can be directly linked to the ability of that toxin to pass through the cell membranes of the organisms, and specific methods have been developed for metal pollutants according to their reacting sites with abiotic environments (van Leeuwen et al. 2005). Finally on-site observation along with molecular characterization with the integration of biological and physicochemical processes can be used to access the ultimate fate of micropollutants in aquatic ecosystems.

2.4.1 Persistent Organic Pollutants

Long back to the dates, persistent organic pollutants are the chemicals of serious concern as they contain intermediate products of various reactions which are unintentional in the origin as from heavy mechanical works and other combustion processes (Bhat et al. 2018a, b). Some criterion has been kept to include chemicals in the persistent organic pollutant category as some of the conditions are discussed below:

1. The POPs will remain in the environment for longer period of time because any chemical or biological reaction will not affect their concentrations.

2. Due to their persistence, the disposal rate of such chemicals is almost negligible.
3. Biomagnification.
4. With high rate of toxicity toward the flora and fauna including humans as well.

In the international convections, namely, Stockholm Convention and Aarhus Protocol, numerous persistent organic pollutants have been included in order to cut the emission rates on the global level (Lohmann et al. 2007). Highly chlorinated compounds like polychlorinated biphenyls, dichlorodiphenyltrichloroethane, and polycyclic aromatic hydrocarbons are the top priority persistent organic pollutants (Muir and Howard 2006). Moreover there are other diffuse sources of persistent organic pollutants which are not even included in the list as due to the recent occurrence of polybrominated diphenyl ethers and perfluoroalkyl-associated chemicals as alarming persistent organic pollutants (Vonderheide et al. 2008; Yoga and Sericano 2009) which have wide industrial application due to their properties of use (Goss and Bronner 2006). Many persistent organic pollutants have shown that they remain active in the atmosphere for hundreds of years, but due to lack of knowledge, they cannot be eliminated from the source in use (Richardson 2009; Giger 2009). Various health ailments like obesity, diabetes, or thyroid, fertility, and immune problems are associated with exposure to the persistent organic pollutants. The marine biota have been found to act as storing bodies where concentration goes on increasing with the rate of consumption (Kelly et al. 2007, 2009). After conducting various histopathological studies, huge concentrations of persistent organic pollutants have been found in marine biota and ultimately find its way to the humans especially in the human milk (Hites 2004 and Porta et al. 2008). In the Arctic region, persistent organic pollutants have shown the marked presence due to huge travel range (Brown and Wania 2008). DDT and PCB are being most traditionally used chemicals as an insecticides which have long persistence but are still in use when banned dates back. In many regions of the world including North America, Europe, and Japan where hundreds of persistent organic pollutants has shown detrimental effects within the human body along with the exposure in 5 years of period and PBDEs have shown their more effects on terrestrial organisms as well as same case has been observed among the mammals of marine ecosystems in the Northern Europe and America (Hites 2004). Hence in order to achieve the goal of complete elimination of persistent organic pollutants, there is a need for the remediation of previous contaminated sites then the newly added chemicals to the environment can be achieved by remediation strategies.

2.4.1.1 Occurrence of Toxic Algae

Due to the availablity of suitable Conditions as algae can flourish and leads to production of various toxins which are hazardous chemicals posing threats to aquatic and terrestrial animals as these algae produces both the toxins, i.e. intracellular and extracellular. These extracellular toxins are being released into the surrounding waters while other organisms become fragile to these contaminants by either feeding on these algal cells or by water absorption cause death to those organsims. All the organisms in any ecosystems whether terrestrial and aquatic organisms are directly or indirectly interlinked via the food chains and food webs as though these toxins can be transferred and accumulated from one organism to another one, for example, from zooplanktons to large fishes and lastly get bioaccumulated into the humans body; hence, affects every single organism. The production of microscopic algae like dinoflagellates, diatoms, and cyanobacteria can be stimulated by inorganic nitrogen contamination which triggers their metabolism to generate more toxins (Anderson et al. 2002).

2.5 Consequences of Water Pollutants

2.5.1 Chemicals in Water that Affect Human Health

Exposure of human beings to the toxicants in their day-to-day life results in acute and chronic diseases as the allowed limit for the fluoride in water should be less than 0.5 mg/litre of water which is essential against the tooth decay and weakening of bones, but exposure to higher levels especially in the age group of 5–6 years causes disease called fluorosis. Tanneries, insecticide for plants, ceramics, coal-fired power plants, and other industries release arsenic into the water bodies, and it also has some natural source of origin like the rocks rich in such metals. It has been already reported in various districts of West Bengal where allowed limits for arsenic have found to be more thus many cases has been registered for complaint of various cancers like prostate and lung cancers and other heart ailments. The plumbing pipes and other sanitary domestic fittings add arsenic to the drinking waters which causes kidney diseases and affects central nervous systems as children and pregnant women are more prone to the lead contaminations. Another toxic metal is the mercury which comes from the smelters, battery production, pesticides, and fungicides; as in 1938, significant amounts of mercury have been dumped from the factory into the Minamata Bay which resulted in the mercury pollution, and fishes accumulated the dumped mercury which found its way to human body after the consumption of these contaminated fishes, and the affected humans has been diagnosed with varying levels of mercury in their blood and tissues; hence the disease is named as Minamata disease due to presence of methyl mercury, as around two thousand were poisoned and hundreds of people were left dead, disabled and ultimately resulted in the chromosomal aberrations and human neurological disorders (Akio 1992). Another breakout was the long-term consumption of rice contaminated with cadmium in regions of Japan which resulted into the disease known as “itai-itai” or “ouch-ouch” as people complained of nephritis and nephrosis (Friberg et al. 1974).

2.5.2 Waterborne Disease

Presence of microorganisms indicates the quality of water as some of the microbes, namely, *Vibrio cholera*, *Salmonella* sp., *Shigella* sp., and *E. coli*, if present in the water will cause diseases like typhoid, diarrhoea, and dysentery after consumption because they are pathogenic microbes in nature (Adetunde and Glover 2010). The main source for these pathogenic microbes is the faeces and untreated sewage which, after direct oral transmission through water or food induce above-mentioned diseases (Adetunde and Glover 2010). It has been reported worldwide that more than 14,000 deaths occurs in a day mostly children of age 5 due to contamination of groundwater (Larry 2006) and also more than 1.1 million children are estimated to die each year because of their low immunity (Steiner et al. 2006).

2.5.3 Acidification of Freshwater Ecosystems

Baker et al. (1991) reported that the cause of acidification in inland waters is due to presence of nitrogen dioxide and sulphur dioxide as they react with water to form nitric acid (HNO_3) and sulphuric acid (H_2SO_4), respectively, after following the various reactions (Mason 1989). Due to fallout from the atmosphere consisting mainly of $SO_4^{2-}$and NO^{3-}, where the concentration of H^+ in freshwater environments with no high acid neutralizing potential (i.e. with moderate or low alkalinity) (Baker et al. 1991). The pH of water decreases on addition of these acids, and acidic pH will lead to accumulation and/or reduced sedimentation of metals like aluminium (Al^{2+}) and other trace metals like zinc, copper, lead, and cadmium. In the acidified lakes, aluminium gets deposited on sediments (Borg et al. 1989; Nelson and Campbell 1991). According to the Skjelkvale et al. (2001), the emission rates for the sulphur dioxide and nitrogen oxides from the Europe and North America in the 1980s and 1990s have been eliminated but their levels remain unregulated and caused acidification of freshwaters (Skjelkvale et al. 2001). Ammonium ions (NH_4^+) lead to release of H^+ ions under the acidic conditions (Wetzel 2001). Hence the inland water bodies around the world has been classified on the basis of their pH values between 4.5 and 5.8, and these lakes and streams are found in the various regions of Northern and Central Europe and North America (Skjelkvale et al. 2001; Doka et al. 2003). The productivity of primary and secondary vegetation of lakes and streams got declined due to acceleration of acidification because of human interventions and in turn affected the invertebrate and important fishes of the lakes and streams (Allan 1995). As per the reports of Doka et al. (2003), when the pH levels of water drops to 6.0 to 5.5, all the biota gets affected because of their fragile enzymatic reactions inside the body. Ultimately the equilibrium of the ecosystem of lakes and streams gets disturbed, hence regulating the concentrations of chlorides, sodium, potassium, and calcium (Allan 1995). As it has been found in various experimental studies conducted over some lakes of Canada with pH below 5.6, the nitrification process of NH_4+ gets hampered (Rudd et al. 1998, 1990).

2.5.4 Ocean Garbage Patches

The flow rate of plastics in the North Pacific Ocean has been estimated around 5–10 million tons that too around the Japan and California as estimated by the UN (Livingeco 2011). The North Pacific Subtropical Gyre is often recognized as "the Great Pacific Ocean Garbage Patch" which is measured to be twofold the size of Texas. Kostigen and Magazine (2008) reported that at the depth of 100 feet large, small plastics in clusters have been found in the Pacific Ocean Gyre and in other associated gyres like of the Southern Atlantic subtropical gyre (SG), North Pacific subtropical Gyre (NPG), and Indian Ocean subtropical gyre. As in Caribbean Seas and parts of the North Atlantic Ocean, two lack tons of plastic per km^2 has been found after surveillance of 20 years (Gill 2010) The major sources for the plastics into the oceans comes from the beaches which accounts for eighty percent 10% from fishing gear and other percent from vessels and ship as well as the cargo ships add containers (McLendon 2010). Nearly about thousands of plastic ducks were lost in the Pacific Ocean between Hong Kong and America, and these are reported to be circulated in oceanic waters as Great Pacific Garbage Patch around the waters of Alaska, South America, Hawaii, Australia, and Pacific Northwest (Nelson 2011).

2.5.5 Marine Biodiversity and Plastic Pollution

Over the last several decades, addition of plastic waste in to the water bodies has significantly increased as the wildlife is often injured due to plastics found in the environment whether intertwined or ingested (Hameed et al. 2020). As per reports of Blight and Burger (1997), a marine class, namely, Procellariiformes, such as the petrels, albatrosses, and shearwaters used to feed on food as the broken plastics seems similar to their food particles i.e. phytoplankton's as after engulfment of these plastic materials moreover these organisms are in turn eaten by small and finally large fishes as per trophic levels. The assimilation of these plastic wastes into the body decreases ability to digest and inhibit progress, causes internal damage, and creates intestinal blockage (Plot and Georges 2010). Fishing nets, or other ring-shaped materials, can contribute to strangulation, feeding efficiency loss, often drowning as of natural curiosity of the pinnipeds which are interwoven into aquatic waste at a young age, thus hinders their body size decreases due to accumulation of marine debris (Allen et al. 2012). All around the world, it has been estimated that 23% of marine mammals especially sea turtles and large population of seabirds ingest plastic debris and tar from oil spills which leads to death of marine mammals as many plastic scraps has been removed after autopsies (Stamper et al. 2009). Ingested plastic debris and tar from oil spills is the leading cause for the death of sea turtles as many plastic scraps has been removed after the autopsies including Styrofoam, fishing lines, plastic bags, etc. as the floating plastic bags seem to be jelly fishes for these turtles (Stamper et al. 2009; Mascarenhas et al. 2004).

Henceforth the population of the *Dermochelys coriacea* (leatherback sea turtles) has declined as now listed as the critically endangered species of IUCN (Shillinger et al. 2012).

2.5.6 Coral Reefs and Water Pollution

The most diverse ecosystem on the planet earth is the coral reefs with the presence of species from algae to the higher mammals with high levels of interaction at diverse levels of hierarchy. Although diverse coral reefs are very fragile for the very small change in their abiotic factors or the available basic necessities like temperature, nutrients etc. which varies from the organism to organism and also with the different age groups. The coral reefs are the organisms which lives in symbiotic association between the hosts coral which is polyps (*Symbiodine* sp.) belonging to the class of Cnidaria and with the algae (Hoegh-Guldberg 1999 and Fabricius et al. 2005). From the past decade, due to high levels of water pollution and global climate change, the temperature and the sea level rise have threatened these coral reef ecosystems all around the world especially of the reefs of Pacific oceans. According to the reports of Stebbing and Brown (1984), the branching coral species appears more susceptible than massive corals to a certain amount of chemical contaminants, and also the small polp species seems more susceptible to pollution stress than large polyp corals on comparison of stage of life, reproductive strategy, mucus and lipid content are used to access the sensitivity of coral groups due to pollutant stress (Scott 1990; Peters et al. 1997). The optimum temperature for the corals should be between 20 and 40 °C on an average, but from the past few years, the temperature of the shallow seas has found to be more by 2 degrees which results in the loss of symbiotic association of coral polyps and algal species and finally the bleaching of corals. Also the washout from the farm fields finds its way to the oceans which consists of fertilizers and pesticides of the chlorinated compounds like DDT, HCB, dieldrin, and chlordane, as the residues remain in the sediments of water and soil for longer periods of time thus affecting the natural balance of coastal waters around the world especially in the developing nations (Mitchell et al. 2005; Packett et al. 2009). The distribution and fate of pesticides and their toxicity to non-targeting populations is therefore critical to the secure evaluation of application-related threats in specific tropical areas with trends of use of pesticides typically well exceeding temperate areas (Ecobichon 2001).

2.6 Climate Change and Water Pollution

According to the Intergovernmental Panel on Climate Change (IPCC), global surface temperature rose by 0.74 °C in the last 100 years (1906–2005). Global warming is thus actually an incontrovertible fact, and the annual warming trend for the last 50 years is almost double that recorded over the previous 100 years (Trenberth et al. 2007). All the biological and even physic-chemical processes of water ecosystems on the globe may get directly or indirectly affected by climate change (Dalla et al. 2007; Delpla et al. 2009; Whitehead et al. 2009). Understanding the different hydrodynamics and biochemistries taking place in numerous waters is the key to understanding the interaction between climate change and water quality in various bodies in water (Delpla et al. 2009; Mooij et al. 2009). Till date so many studies has been conducted to identify and classify the source, origin, and effects of various types of pollutants like eutrophication, salinization, nutrient release, aquatic plant growth, and long-term climate change effects on the inland waters, surface waters, seas, and oceans. As due to temperature rise or the global climate change, the hydrodynamics of the water system including thermoprofile and chemoprofile of entire water column gets totally disturbed in the deep lakes and reservoirs (Brooks et al. 2011).

It has been observed that for some North American and European Lakes since the 1960s, the stratification process has been extended from 20 days to 40 days (Rosenzweig et al. 2007; Delpla et al. 2009). The exchange of surface and groundwater has hampered for the process of thermal stratification due to reduction of dissolved oxygen levels and excessive accumulation of carbon dioxide which leads to easy formation of a reductive environment (Rasmussen et al. 2009). However, several scientific reports have shown that the loss of nutrients and other toxins from the soil due to low water hypoxia (Gantzer et al. 2009). In recent times, the temperature rose by 3.8 °C in 2019 to 2100 under the A2 scenario in contrast to the reference duration from 1991 to 2001after conducting experiments over Shimajigawa's reservoir of Western Japan. According to Komatsu et al. (2007) by deepening of an anaerobic layers in the waters by 6.6 meters will ultimately advance the PO^4 concentration from 1.7 to 5.6 μg/L in the surface water due to more fluxes of phosphorus and an increase in the chlorophyll a concentration from 7.8 to 16.5 μg/L. Though mineralization and salinization for the long run will eventually affect equilibrium conditions of lakes and streams due to climate change which will lead the waters unfit for drinking purposes. According to the results obtained by Liu et al. (2004), on the Hei River Basin, an increase in the temperature and a decrease in the runoff have been the major reasons for the mineralization of lakes since the early 1960s. Liu et al. (2004) deduced that the mineralization of Chaiwobao Lake and Hongjianzhuo Lake in Xinjiang Province was also associated with climate change.

2.7 Conclusions

Pollution of water is an alarming problem in the world and must be dealt with sustainably. The framework of research and development should be strengthened in order to develop and develop new innovative technologies with financial feasibility. In river basins and catering areas of bodies of water, the construction practices of factories, industrial projects, irrigation, and other infrastructures should not be allowed to limit the contamination of rivers, lakes, and others. In addition, the comprehensive environmental preparation should be applied with legal support through well-defined simulation models with the main aim of preserving or restoring water quality.

References

Adeogun AO, Ibor OR, Adeduntan SD, Arukwe A (2016) Intersex and alterations in reproductive development of a cichlid, Tilapia guineensis, from a municipal domestic water supply lake (Eleyele) in Southwestern Nigeria. Sci Total Environ 541:372–382

Adetunde LA, Glover RL (2010) Bacteriological quality of borehole water used by students' of University for development studies, Navrongo campus in upper-east region of Ghana. Curr Res J Biol Sci 2:361–364

Akio M (1992) Bitter sea: the human cost of Minamata disease, 1st edn. Kosei Publishing, Tokyo

Allan JD (1995) Stream ecology: structure and function of running waters. Chapman and Hall, London

Allen R, Jarvis D, Sayer S, Mills C (2012) Entanglement of grey seals Halichoerus grypus at a haul out site in Cornwall, UK. Mar Pollut Bull 64:2815–2819

An Q, Wu YQ, Taylor S, Zhao B (2009) Influence of the Three Gorges Project on saltwater intrusion in the Yangtze River estuary. Environ Geol 56:1679–1686

Anderson BA, Romani JH, Phillips HE, van Zyl JA (2002) Environment, access to health care, and other factors affecting infant and child survival among the African and Coloured populations of South Africa, 1989–94. Popul Environ 23:349–364

Baig JA, Kazi TG, Arain MB, Afridi HI, Kandhro GA, Sarfraz RA, Jamali MK and Shah AQ (2009). Evaluation of arsenic and other physico -chemical parameters of surfaceand ground water of Jamshoro, Pakistan. J Hazard Mater 166:662–669

Baker LA, Herlihy AT, Kaufmann PR, Eilers JM (1991) Acidic lakes and streams in the United States: the role of acidic deposition. Science 252:1151–1154

Bhat RA, Shafiq-ur-Rehman, Mehmood MA, Dervash MA, Mushtaq N, Bhat JIA, Dar GH (2017) Current status of nutrient load in Dal Lake of Kashmir Himalaya. J Pharmacogn Phytochem 6(6):165–169

Bhat RA, Beigh BA, Mir SA, Dar SA, Dervash MA, Rashid A, Lone R (2018a) Biopesticide techniques to remediate pesticides in polluted ecosystems. In: Wani KA, Mamta (eds) Handbook of research on the adverse effects of pesticide pollution in aquatic ecosystems. IGI Global, Hershey, pp 387–407

Bhat RA, Dervash MA, Mehmood MA, Hakeem KR (2018b) Municipal solid waste generation and its management, a growing threat to fragile ecosystem in Kashmir Himalaya. Am J Environ Sci. https://doi.org/10.3844/ajessp.2018

Blight LK, Burger AE (1997) Occurrence of plastic particles in seabirds from the eastern North Pacific. Mar Pollut Bull 34:323–325

Bockstaller C, Guichard L, Keichinger O, Girardin P, Galan MB, Gaillard G (2009) Comparison of methods to assess the sustainability of agricultural systems. A Rev Agron Sustain Dev 29:223–235

Borg H, Andersson P, Johansson K (1989) Influence of acidification on metal fluxes in Swedish forest lakes. Sci Total Environ 87/88:241–254

Brady D, Stoll AD, Starke L, Duncan JR (1994) Bioaccumulation of metal cations by Saccharomyces cerevisiae. Appl Microbiol Biotechnol 41:149–154

Brooks B, Valenti T, Valenti WT, Cook-Lindsay AB, Forbes GM, Doyle DR, Scott TJ, Stanley KJ (2011) Influence of climate change on reservoir water quality assessment and management. Climate:491–522

Brown TN, Wania F (2008) Screening chemicals for the potential to the persistent organic pollutants: a case study of Arctic contaminants. Environ Sci Technol 42:5202–5209
Bruins MR, Kapil S, Oehme FW (2000) Microbial resistance to metals in the environment. Ecotoxicol Environ Saf 45:198–207
Bu H, Tan X, Li S and Zhang Q (2010) Water quality assessment of the Jinshui River(China) using multivariate statistical techniques. Environ Earth Sci 60:1631–1639
Carpenter SR, Caraco NF, Correll DL, Howarth RW, Sharpley AN, Smith VH (1998) Non point pollution of surface waters with pho sphorus and nitrogen. Ecol Appl 8:559–568
Clasen T, Schmidt WP, Rabie T, Roberts I, Cairncross S (2007) Interventions to improve water quality for preventing diarrhoea: systematic review and meta-analysis. Br Med J 334:782
Cosgrove WJ, Rijsberman FR (2000) World water vision: making water everybody's business. World Water Council, London
Dalla Valle M, Codato E, Marcomini A (2007) Climate change influence on POPs distribution and fate: a case study. Chemos 67:1287–1295
Das RK, Bhowmick S, Ghosh SP, Dutta S (1997) Coliform and fecal coliform bacterial load in a stretch of Hooghly. In: Proceedings of the National seminar on changing perspectives of inland fisheries. Inland Fisheries Society of India, Barrackpore, pp 11–16
Delpla I, Jung VA, Baures E, Clement M, Thomas O (2009) Impacts of climate change on surface water quality in relation to drinking water production. Environ Int 35:1225–1233
Doka SE, McNicol DK, Mallory ML, Wong I, Minns CK, Yan ND (2003) Assessing potential for recovery of biotic richness and indicator species due to changes in acidic deposition and lake pH in five areas of southeastern Canada. Environ Monit Assess 88:53–101
Ecobichon DJ (2001) Pesticide use in developing countries. Toxicology 160:27–33
Eliopoulou E, Papanikolaou A (2007) Casualty analysis of large tankers. J Mar Sci Technol 12:240–250
Fabricius K, De'ath G, McCook L, Turak E, Williams DM (2005) Changes in algal, coral and fish assemblages along water quality gradients on the inshore Great Barrier Reef. Mar Pollut Bull 51:384–398
Filippelli GM (2008) The global phosphorus cycle: past, present, and future. Elements 4:89–95
Friberg L, Piscator M, Nordberg GF, Kjellstrom T (1974) Cadmium in the environment, 2nd edn. Chemical Rubber Company Press, Cleveland, p 248
Gantzer PA, Bryant DL, Little CJ (2009) Controlling soluble iron and manganese in a water-supply reservoir using hypolimnetic oxygenation. Water Res 43:1285–1294
Ghosh S, Vass KK (1997) Role of sewage treatment plant in environmental mitigation. In: Vass KK, Sinha M (eds) Proceedings of the national seminar on changing perspectives of inland fisheries. Inland Fisheries Society of India, Barrackpore, pp 36–40
Giger W (2009) Hydrophilic and amphiphilic water pollutants: using advanced analytical methods for classic and emerging contaminants. Anal Bioanal Chem 393:37–44
Gill V (2010) Plastic rubbish blights Atlantic Ocean. BBC News 24
Goolsby DA, Battaglin WA (2001) Long-term changes in concentrations and flux of nitrogen in the Mississippi River Basin, U.S.A. Hydrol Process 15:1209–1226
Goss KU, Bronner G (2006) What is so special about the sorption behavior of highly fluorinated compounds? J Phys Chem A 110:9518–9522
Gruber N, Galloway JN (2008) An earth-system perspective of the global nitrogen cycle. Nature 451:293–296
Hameed M, Bhat RA, Singh DV, Mehmood MA (2020) White pollution: a Hazard to environmental and sustainable approach to its management. In: Bhat RA, Qadri H, Wani KA, Dar GH, Mehmood MA (eds) Innovative waste management technologies for sustainable development. IGI Global, Hershey, pp 52–81
Hanslmeier A (2011) Water in the universe, vol 368. Springer Science & Business Media
Harikishore RK, Lee SM (2012) Water Pollution and Treatment Technologies. J Environ Anal Toxicol, 2:4, 103. https://doi.org/10.4172/2161-0525.1000e103

Heisler J, Glibert PM, Burkholder JM, Anderson DM, Cochlan W, Dennison WC, Dortch Q, Gobler CJ, Heil CA, Humphries E, Lewitus A (2008) Eutrophication and harmful algal blooms: a scientific consensus. Harmful Algae 8:3–13
Hites RA (2004) Polybrominated diphenyl ethers in the environment and in people: a meta-analysis of concentrations. Environ Sci Technol 38:945–956
Hoegh-Guldberg O (1999) Climate change, coral bleaching and the future of the world's coral reefs. Mar Freshw Res 50:839–866
Howarth RW, Billen G, Swaney D, Townsend A, Jaworski N, Lajtha K, Downing JA, Elmgren R, Caraco N, Jordan T, Berendse F (1996) Regional nitrogen budgets and riverine N & P fluxes for the drainages to the North Atlantic Ocean: natural and human influences. Biogeochemistry 35:181–226
Inyinbor AA, Adekola FA, Olatunji GA (2016) Liquid phase adsorption of Rhodamine B dye onto acid-treated Raphia hookeri fruit epicarp: isotherms, kinetics and thermodynamics studies. S Afr J Chem 69:218–226
ISI (1982) Indian standard tolerance limits for inland surface water subject to pollution, 2nd. revision. Indian Standard Institute, New Delhi, 2296
Jain VK (1978) Studies on effect of cadmium on the growth pattern of Phaseolus aureus varieties, Absi, I. Bot. Conf. JIBS, pp 57–84
Jorgenson AK (2009) Political-economic integration, industrial pollution and human health: a panel study of less-developed countries, 1980–2000. Int Sociol 24:115–143
Kaushal SS, Groffman PM, Likens GE, Belt KT, Stack WP, Kelly VR, Band LE, Fisher GT (2005) Increased salinization of fresh water in the northeastern United States. Proc Natl Acad Sci 102:13517–13520
Kelly BC, Ikonomou MG, Blair JD, Morin AE, Gobas F (2007) Food web-specific biomagnification of persistent organic pollutants. Sci 317:236–239
Kelly BC, Ikonomou MG, Blair JD, Surridge B, Hoover D, Grace R, Gobas FA (2009) Perfluoroalkyl contaminants in an Arctic marine food web: trophic magnification and wildlife exposure. Environ Sci Technol 43:4037–4043
Kgalushi R, Smite S, Eales K (2004) People living with HIV/AIDS in a context of rural poverty: the importance of water and sanitation services and hygiene education. Mvula Trust and Delft: IRC International Water and Sanitation Centre, Johannesburg
Kock Rasmussen E, Svenstrup Petersen O, Thompson RJ, Flower JR, Ahmed HM (2009) Hydrodynamic-ecological model analyses of the water quality of Lake Manzala (Nile Delta, Northern Egypt). Hydrobiologia 622:195–220
Komatsu E, Fukushima T, Harasawad H (2007) A modeling approach to forecast the effect of long-term climate change on lake water quality. Ecol Model 209:351–366
Kostigen TM, Magazine FD (2008) The world's largest dump: the great pacific garbage patch. Discover Magazine 10
Larry W (2006) World water day. A billion people worldwide lack safe drinking
Larsen TA, Maurer M, Udert KM, Lienert J (2007) Nutrient cycles and resource management: implications for the choice of wastewater treatment technology. Water Sci Technol 56:229–237
Laurent P (2005) Household drinking water systems and their impact on people with weakened immunity. MSF-Holland, Public Health Department
Liu W, Wang T, Gao X, Su Y (2004) Distribution and evolution of water chemical characteristics in Heihe River Basin. J Desert Res 24:755–762
Livingeco (2011) The clean oceans project/plastic to oil machine
Lohmann R, Breivik K, Dachs J, Muir D (2007) Global fate of POPs: current and future research directions. Environ Pollut 150:150–165
Lohse KA, Brooks PD, McIntosh JC, Meixner T, Huxman TE (2009) Interactions between biogeochemistry and hydrologic systems. Annu Rev Environ Resour 34:65–96
Manceau A, Marcus MA, Tamura N (2002) Quantitative speciation of heavy metals in soils and sediments by synchrotron X-ray techniques. Rev Mineral Geochem 49:341–428

Mascarenhas R, Santos R, Zeppelini D (2004) Plastic debris ingestion by sea turtle in Paraí ba, Brazil. Mar Pollut Bullet 49:354–355
Mason J (1989) Introduction: the causes and consequences of surface water acidification. In: Morris R, Taylor EW, Brown DJA, Brown JA (eds) Acid toxicity and aquatic animals. Cambridge University Press, Cambridge, pp 1–12
McLendon R (2010) What is the Great Pacific Ocean Garbage Patch? Mother Nature Network:24
Mintz E, Bartram J, Lochney P, Wegelin M (2001) Not just a drop in the bucket: expanding access to point-of-use water treatment systems. Am J Public Health 91:1565–1570
Mitchell C, Brodie J, White I (2005) Sediments, nutrients and pesticide residues in event flow conditions in streams of the Mackay Whitsunday Region, Australia. Mar Pollut Bull 51:23–36
Mooij W, De Senerpont Domis L, Janse HJ (2009) Linking species and ecosystem-level impacts of climate change in lakes with a complex and a minimal model. Ecol Model 220:3011–3020
Muir DC, Howard PH (2006) Are there other persistent organic pollutants? A challenge for environmental chemists. Environ Sci Technol 40:7157–7166
Nelson B (2011) What can 28,000 rubber duckies lost at sea teach us about our oceans? Mother Nature Network
Nelson WO, Campbell PG (1991) The effects of acidification on the geochemistry of Al, Cd, Pb and Hg in freshwater environments: a literature review. Environ Pollut 71:91–130
Okeke CO, Igboanua AH (2003) Characteristics and quality assessment of surface water and groundwater resources of Akwa Town, Southeast, Nigeria. J Niger Assoc Hydrol Geol 14:71–77
Packett R, Dougall C, Rohde K, Noble R (2009) Agricultural lands are hot-spots for annual runoff polluting the southern Great Barrier Reef lagoon. Mar Pollut Bull 58:976–986
Paul MJ, Meyer JL (2001) Streams in the urban landscape. Annu Rev Ecol Syst 32:333–365
Peters EC, Gassman NJ, Firman JC, Richmond RH, Power EA (1997) Ecotoxicology of tropical marine ecosystems. Environ Toxicol Chem 16:12–40
Plot V, Georges JY (2010) Plastic debris in a nesting leatherback turtle in French Guiana. Chel Conser Biol 9:267–270
Plumlee GS, Morman SA, Ziegler TL (2006) The toxicological geochemistry of earth materials: an overview of processes and the interdisciplinary methods used to understand them. Rev Mineral Geochem 64:5–7
Porta M, Puigdomènech E, Ballester F, Selva J, Ribas-Fitó N, Llop S, López T (2008) Monitoring concentrations of persistent organic pollutants in the general population: the international experience. Environ Int 34:546–561
Post VE (2005) Fresh and saline groundwater interaction in coastal aquifers: is our technology ready for the problems ahead? Hydrogeol J 13:120–123
Ramakrishnaya CR, Sadashivalah C and Ranganna G (2009). Assessment of water quality index for groundwater in Tumkur Taluk, Karnataka State. Indian J Chem 6:523–530
Rana RS, Singh P, Kandari V, Singh R, Dobhal R, Gupta S (2017) A review on characterization and bioremediation of pharmaceutical industries' wastewater: an Indian perspective. Appl Wat Sci 7:1–12
Richardson SD (2009) Water analysis: emerging contaminants and current issues. Anal Chem 81:4645–4677
Roberts LC, Hug SJ, Dittmar J, Voegelin A, Kretzschmar R, Wehrli B, Cirpka OA, Saha GC, Ali MA, Badruzzaman AB (2010) Arsenic release from paddy soils during monsoon flooding. Nat Geosci 3:53–59
Rosenzweig C, Casassa G, Karoly DJ, Imeson A, Liu C, Menzel A, Rawlins S, Root TL, Seguin B, Tryjanowski P, Parry ML (2007) Assessment of observed changes and responses in natural and managed systems
Rudd JW, Kelly CA, Schindler DW, Turner MA (1990) A comparison of the acidification efficiencies of nitric and sulfuric acids by two whole-lake addition experiments. Limnol Oceanogr 35:663–679
Rudd JW, Kelly CA, Schindler DW, Turner MA (1998) Disruption of the nitrogen cycle in acidified lakes. Science 240:1515–1517

Schwarzenbach RP, Gschwend PM, Imboden DM (2003) Environmental organic chemistry. Wiley pp 1311, New York

Schwarzenbach RP, Escher BI, Fenner K, Hofstetter TB, Johnson CA, Von Gunten U, Wehrli B (2006) The challenge of micropollutants in aquatic systems. Science 313:1072–1077

Schwarzman MR, Wilson MP (2009) New science for chemicals policy. Science 326:1065–1066

Scott PJ (1990) Chronic pollution recorded in coral skeletons in Hong Kong. J Exp Mar Biol Ecol 139:51–64

Shao M, Tang XY, Zhang YH, Li WJ (2006) City clusters in China: air and surface water pollution. Front Ecol Environ 4:353–361

Shillinger GL, Di Lorenzo E, Luo H, Bograd SJ, Hazen EL, Bailey H, Spotila JR (2012) On the dispersal of leatherback turtle hatchlings from Mesoamerican nesting beaches. Proc R Soc B Biol Sci 279:2391–2395

Skjelkvale BL, Stoddard JL, Andersen T (2001) Trends in surface water acidification in Europe and North America (1989–1998). Water Air Soil Pollut 130:787–792

Stamper MA, Spicer CW, Neiffer DL, Mathews KS, Fleming GJ (2009) Morbidity in a juvenile green sea turtle (Chelonia mydas) due to ocean-borne plastic. J Zoo Wildl Med 40:196–198

Stebbing AR, Brown BE (1984) Marine ecotoxicological tests with coelenterates. In: Persoone G, Jaspers E, Claus C (eds) Ecotoxicological testing for the marine environment. State University of Ghent and Institute of Marine Scientific Research, Bredene, pp 307–340

Steiner TS, Samie A, Guerrant RL (2006) Infectious diarrhea: new pathogens and new challenges in developed and developing areas. Clin Infect Dis 43:408–410

Teutsch N, Schmid M, Muller B, Halliday AN, Burgmann H, Wehrli B (2009) Large iron isotope fractionation at the oxic-anoxic boundary in Lake Nyos. Earth Planet Sci Lett 285:52–60

Trenberth KE, Jones PD, Ambenje P, Bojariu R, Easterling D, Tank AK, Parker D, Rahimzadeh F, Renwick JA, Rusticucci M, Soden B (2007) Observations: surface and atmospheric climate c hange. Chapter 3. Climate Change 15:235–336

Tsuji LJ, Karagatzides JD (2001) Chronic lead exposure, body condition and testis mass in wild Mallard Ducks. B Environ Contam Tox 67:489–495

United Nations Children's Fund (UNICEF) (2010) Progress on sanitation and drinking water. UNICEF, New York

van Leeuwen HP, Town RM, Buffle J, Cleven RF, Davison W, Puy J, van Riemsdijk WH, Sigg L (2005) Dynamic speciation analysis and bioavailability of metals in aquatic systems. Environ Sci Technol 39:8545–8556

Vidyasagar D (2007) Global minute: water and health – walking for water and water wars. J Perinatol 27:56–58

Vonderheide AP, Mueller KE, Meija J, Welsh GL (2008) Polybrominated diphenyl ethers: causes for concern and knowledge gaps regarding environmental distribution, fate and toxicity. Sci Total Environ 400:425–436

Watson SB (2004) Aquatic taste and odor: a primary signal of drinking-water integrity. J Toxicol Environ Health 67:1779–1795

Wang Q, Yang Z (2016) Industrial water pollution, water environment treatment, and health risks in China. Environ Pollut 218:358–365

Wetzel RG (2001) Limnology, 3rd edn. Academic Press, New York

Whitehead P, Wilby R, Battaree WR, Kernan M, Wade JA (2009) A review of the potential impacts of climate change on surface water quality. Hydrol Sci J 54:101–123

World Health Organization (2010) UN-Water global annual assessment of sanitation and drinking-water (GLAAS) 2012 report: the challenge of extending and sustaining services

Yogui GT, Sericano JL (2009) Polybrominated diphenyl ether flame retardants in the US marine environment: a review. Environ Int 35:655–666