Water Pollutants: Origin and Status

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Abstract Water is the core of life that helps us to exist and also, the most vivacious that keeps us alive. It is essential for all to drink clean and pure water. Due to natural and anthropogenic sources, water becomes polluted that results in the origin of different water pollutants. These water pollutants need to be eliminated from the water for liveliness of people and protect them from various diseases. For instance, water pollution in Rajasthan is due to the indulgence of different industries. Likewise, in Rajasthan many states are affected by water pollution badly. Not only India, whole world suffers from the identical issues. The discharge of chemicals as well as heavy metals through industries and factories are the major sources of water pollution. It is reported that one of the largest sources for this is untreated sewage, discharge into rivers that ultimately affects environment and thus, finally human beings. Human beings contribute in an enormous way to pollute water. Education related to environment should be given to the students and common people so that this problem can be reduced to a certain level. This chapter focuses mainly on the origin of different water pollutants and their current status in the environment.

Keywords Water pollutants · Status · Origin · Diseases · Humans · Environment

1 Introduction

Water is the most vital component in the origin of life. Without water, life is not possible. But it got contaminated by various toxic, inorganic industrial pollutants that results in several problems such as unsafe for consumption for humans and irrigation activities. This leads to water scarcity because it limits its availability for humans and ecosystem.

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The main reason behind water crisis is water pollution. It should not be polluted to a certain threshold value for being used in irrigation and drinking water purposes [1].

The issue of social justice is compounding the water crisis; poor people are more likely to lack clean water and hygiene in comparison to rich one in related areas. Worldwide, enriching water safety, hygiene and sanitation could evade up to 9% of all diseases and 6% of all deaths. Apart from the worldwide waterborne disease crisis, global water quality is threatened by chemical pollution from agricultural activities, industries, cities, and mining areas. Certain chemical pollutants have severe health effects, while many others have long-term that are poorly known. More than 40,000 water bodies in the U.S. currently suitable the EPA description of "impaired," that means they can't sustenance a healthy ecosystem or meet water quality standards. Water pollution is contamination of water by an excess of a substance that can cause impairment to the people and/or the ecosystem [1]. The water pollution level subject to pollutant's abundance, pollutant's ecological impact, and water use. Pollutants derive from chemical, biological, or physical actions. Whereas natural activities such as volcanic eruptions or evaporation can sometimes cause water pollution, the major pollution is a consequent of human activities based on land. As water progresses all the way through stages of the water cycle, water pollutants can move through different water reservoirs. Water residence time (the average time spent in a water reservoir by a water molecule) is extremely imperative for pollution problems as it have an impact on the potential for pollution. Water in rivers has a relatively short period of residence, so there is generally only pithy pollution. Naturally, river pollution can merely move to another reservoir, for instance the ocean, where it can be the reason for further problems. Groundwater is characteristically categorized by sluggish flow and extensive residence time, that can pose a particular problem to groundwater pollution [2]. Lastly, residence time of pollution is greater in comparison to water because a pollutant can be used in the ecosystem for a long time. Pollutants arrive in the water supplies from different kinds of point sources that are easily recognizable and comparatively small, or nonpoint sources that are larger and greater diffuse areas. Point pollution sources comprise of farms in the animal factory that produce huge number and high live-stock densities such as cows, pigs and chickens. Collective sewer systems for bringing together street sewage and storm water runoff for treating wastewater can be major point pollutant sources. Storm water runoff may overdo sewer capacity during heavy rain, triggering it to back up and directly spill untreated sewage into surface waters [3]. Agricultural fields, cities and abandoned mines are nonpoint sources of pollution. Rainfall runs across the land and through the ground for collecting contaminants from agricultural fields and lawns such as herbicides, pesticides, and fertilizers; oil, animal waste, and urban road salt; and acid and toxic elements from abandoned mines. This pollution is then transferred to surface and groundwater [1].

2 History of Water Pollution

Ancient Times: Water forms like rivers, lakes and streams were in the ancient times the source of drinking water. However, human waste was deposited in the same water bodies. Therefore, in rivers became so polluted that in order to obtain clean drinking water, these ancient cultures needed to build aqueducts [4]. The main cause for polluted water was that its way to rivers and streams that were originate by human waste.

Medieval Times—1800s: During this time, people were unaware of what was good for them and what was bad. Mercury was frequently dumped into water and was allowable to run freely into lakes and streams from most of the humans and farm waste. Most people living in metropolises just dumped their waste and garbage onto the street that smelled very bad, probably.

Civilization made many great strides during the latter half of this period, frequently to the damage of the ecosystem. Individuals even consumed chemicals at that time

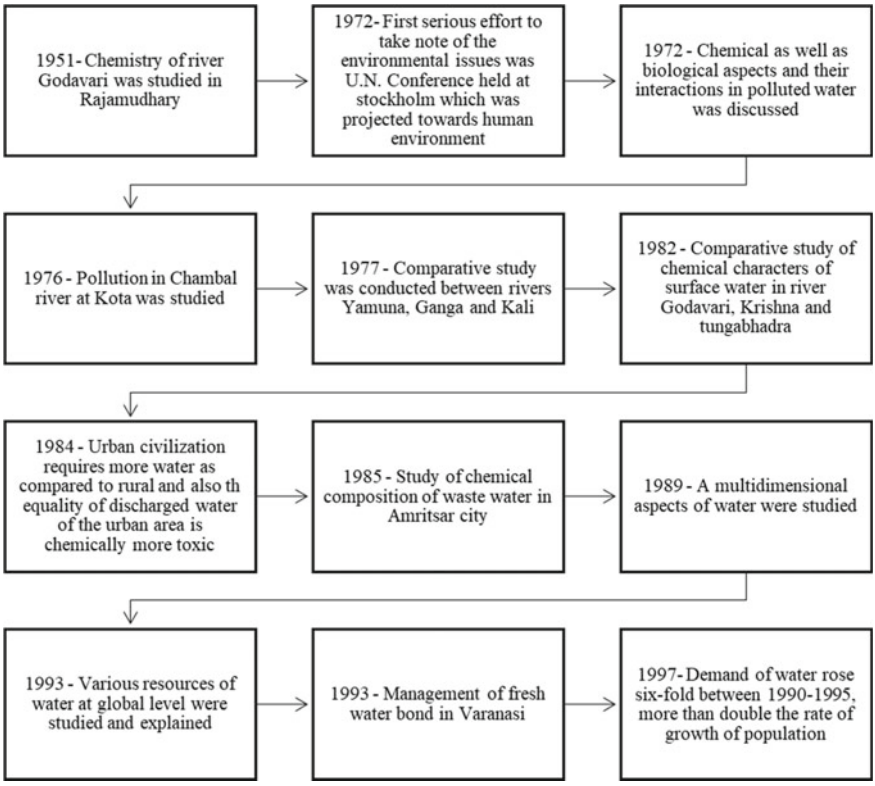

Fig. 1 Flow chart representing different studies on the water contamination at different sites

as they thought, it's good for their health. For the benefit of industry, the Industrial Revolution of the 1800s saw little care for the ecological impact. Many chemical substances have been dumped into the rivers. At that time, people were not concerned about the environmental impact of their inventions [5].

After World War-II: Besides contaminants such as human waste, composts, leather tanning and slaughtering waste, the development of industries and factories had also resulted in much water pollution problems. As waste from industries dumped into river freely without care about the environment were affecting ecology and humans, including flora and fauna [6].

1969: After a series of fires on the Cuyahoga River in 1969, it was realized that fires were triggered by oil slicks and dumped into it by flammable industrial waste. The government then began the studies that allowed the 1972 Clean Water Act to be enacted [4].

Present Day: Many people still do not know how to guard themselves against chemical toxins and waterborne diseases, even with this act. Many cleanups on a large scale have been going on for years [1] (Fig. 1 represents different studies that had done in different sites to check contamination of water).

3 Origin of Water Pollution

The origin of pollutants can be attributed to their fundamental occurrence on earth, the development of natural products by transformation, and their man-made synthesis. The particulates might well arise indeed very naturally to form part of the ecological background exposure levels Many of them are excreted by the organisms or detoxified. Examples of some pollutants that occur naturally are nitrogen oxides, heavy metals. Hydrocarbons and substances that are radioactive [7].

Some pollutants can be formed during their domestic, agricultural or industrial use by concentration and transformation of naturally occurring compounds. The generation of sewage and waste waters comprising agrochemicals, pesticides, petrochemicals hydrocarbons, heavy metals, and radio nuclides are some important examples of pollutants that have emerged from this.

Many of the chemicals do not occur in the nature and the pollution they cause is entirely manmade. For example, the synthesis of various pesticides, surfactants, plastics and petrochemicals has created a large number of chemicals in the environment that have created serious environmental problems [2].

Figure 2 represents how the release of toxic chemicals can be done and how humans and animals get affected with the contaminated water.

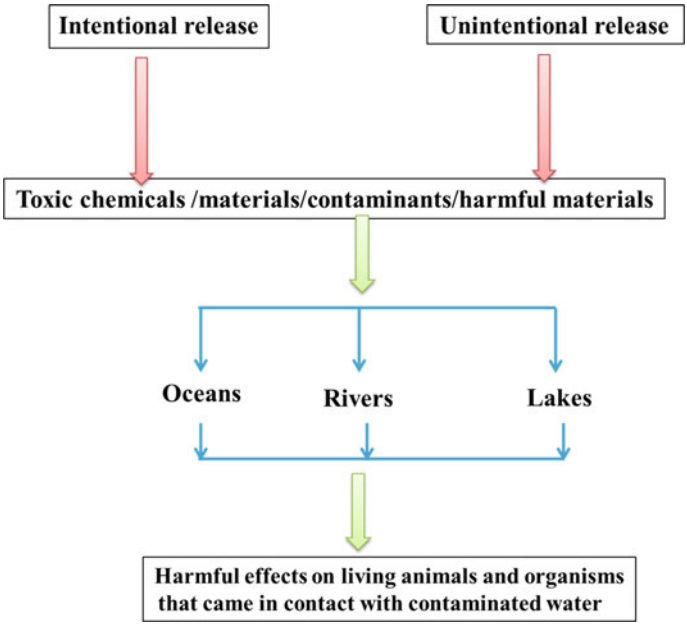

Fig. 2 A diagrammatic representation of release of toxic chemicals in various water bodies

4 Sources of Water Pollutants

The major sources of water pollution that result in contamination are direct and indirect ones, in addition to other sources.

Direct pollution is caused by releasing fluids directly into the water, such as a company that expels contaminated water or toxic solids mixed directly with water into the sea or river. This makes the water poisonous, every so often resulting in death, for fish and other aquatic creatures. Nevertheless, animals also drink this water, which also bring to them ill health or death. It can also affect to humans. In developed countries, people no longer depend on drinking water from the stream or river. There is still a risk for those who swim in or participate in activities such as canoeing on polluted water, as some of them can cause illness and even death [8].

Indirect water pollution is not caused by the introduction of contaminants directly into the water, but by those that end up there. An example includes fertilizer and pesticide chemicals that are washed slowly through the soil and find their way into groundwater and then into various watercourses. In addition, air pollution can cause acid rain to fall to the ground, which can be extremely harmful to wildlife, including polluting lakes, streams and shores, and make the water deadly for those creatures that leave in and near it [8].

Whether it's direct or indirect water pollution (Fig. 3), the results can still be the same, i.e. disease and possibly death to any living thing that lives in it or takes in

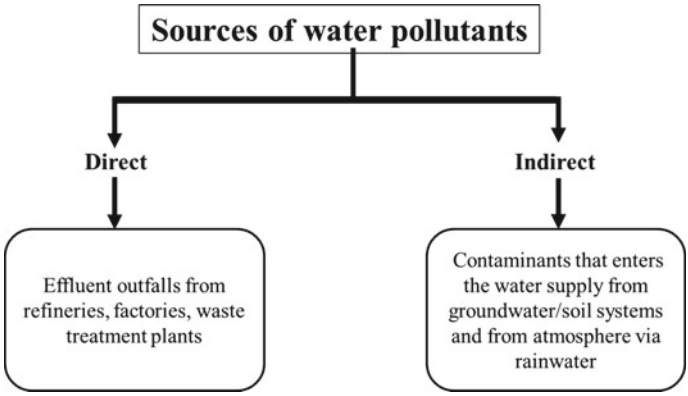

Fig. 3 Sources of water pollutants

water. Therefore, it is imperative that individuals and businesses take steps to reduce their levels of pollution and reduce their environmental impact [9].

The common sources of water pollution can vary from wholly natural to man-made sources such as release of domestic and industrial waste waters.

(a) **Natural Sources and Runoff**

The natural entry of pollutants in water reservoirs can be done through various activities as given below.

1. Rain water
2. Atmosphere (dust, storms)
3. Underground rocks and volcanoes
4. Natural run off
5. Surrounding vegetation

Rain water is an important natural source of water pollution, which dissolves the pollutants from air and brings down the entrained particulate matter with it. E.g. Occurrence of acid rain formed due to the dissolution of acid gases such as oxides of Sulphur and nitrogen in rainwater. The direct deposition of particulate by gravity is called dry deposition is another way of causing water pollution.

The falling of leaves, twigs and other parts of surrounding vegetation can also enrich waters. Presence of underground rocks and volcanoes beneath the water bodies may also be the source of certain kinds of salts [5].

(b) **Domestic Sewage**

Domestic Sewage comprises of waterborne wastes of the public and contains about 99% of water and 1% of solids. Of the solids existing in sewage, 70% are organic and 30% are inorganic in nature. Out of the organic constituents 65% are proteins, 25% carbohydrates and 10% fat. Inorganic fraction of sewage constitutes grit, salts and metals in varying proportions.

The major problems associated with sewage are production of odors and spread of enteric diseases besides organic pollution which leads to oxygen depletion and fish-kill. Sewage also contains huge quantities of nutrients in the form of N_2 and PO_4^{3-} even after secondary treatment that often result in the problem of eutrophication.

Another common way of sewage disposal is its land treatment or crop irrigation. However, disposal in this way, without scientific considerations, can lead to the severe health hazards and deterioration of land in the long run [10].

(c) Agricultural Wastes

Agricultural waste is the waste that originate generally from run-off from cultivated arenas and animal farms. In the recent time, for promoting the growth of fruits and vegetables, farmers add various kinds of agrochemicals that cause many kinds of pollution problems. It can cause toxicity to aquatic life also [11].

(d) Industrial Wastes

Industrial waste is a waste that possess the potential for polluting water reservoirs directly. Nature of industrial waste can vary from industry to industry and also on time as it depends on the usage and type of raw materials used, different processes and also operational factors. It is mentioned that industrial wastes are rich in organic matter [1].

A Table 1 described above to show different sources of pollutants. These pollutants have different components and their respective effects on humans. Thus, there is a need to control these pollutants so that it will not affect humans at a toxic level. That's why some solutions are given in table that needs to be consider.

Table 1 Sources of water pollutants with their effects and corresponding solutions [28, 29]

Sources	Components/pollutants and their effects	Solutions
Agricultural run-offs and mill-waste	NO_3^- and PO_4^{3-} (in fertilizers) • Excess amount results to **eutrophication**	Control its use by (a) using only when crops are growing (b) not using on bare fields (c) not applying when there is a prediction of rain (d) not disposing in river
	Herbicide and pesticide residues • Accretion of pesticides and herbicides have lethal effects on organisms in the water and also to the humans • Level of pesticides start to build up as it passes over the food chain • High dose of pesticides may collect in the tissues of	• Use pesticides that are biodegradable • Use methods to control biological pest • Plant must be genetically modified so that it can resist attacks by pests as this may reduce the need of chemical insecticides

(continued)

Table 1 (continued)

Sources	Components/pollutants and their effects	Solutions
	ultimate consumers that are mostly carnivores	
Untreated sewage consisting mainly of human faeces and domestic waste	Suspended solids • Reduced penetration of light • If suspended solids are biodegradable, microorganisms can decompose them and their processes require a high oxygen requirement	• Before entering rivers, treat sewage • Help to stop the farm slurry (liquid manure) from entering into rivers and ponds
	NO_3^- and PO_4^{3-} • Results into eutrophication	
Domestic waste includes detergents and food waste	**Detergent** • 'Hard' detergents create foam that reduces oxygen supply to water-borne organisms • Soft detergents are biodegradable but it may contain high phosphate levels that can sometimes give rise to eutrophication	• Use low-phosphates biodegradable detergents
Animal waste from farm	Microorganisms such as bacteria and protozoa • If water would be used to drink, perhaps it will cause waterborne diseases namely cholera to be properly treated	• Drink water that is properly treated and boiled
Effluents from industries • Electronic and electroplating plants • Food and beverage processing industry • Rubber product processing industry	**Heavy metals** such as Cu, Hg, Zn and Cr • Highly toxic accumulation through the food chain in the organism • Mercury can cause acute human nervous disorder. Waste water contains numerous contaminants, including sulphide of hydrogen	• Treat effluent before discharging it into bodies of water • File a law suit against hazardous waste dumping
Underground pipes	**Lead** • Lead is highly poisonous heavy metals that could build up in living organism tissues • Lead may affect children's mental capability	• Use copper pipes in plumbing rather than lead pipes

5 Types of Water Pollutants

There are various types of pollutants categorized as:

(a) Organic Pollutants
(b) Inorganic Pollutants
(c) Radioactive Pollutants
(d) Suspended Solid
(e) Pathogens
(f) Nutrients and Agricultural Pollutants
(g) Thermal Pollution.

These pollutants are described as follows:

(a) **Organic Pollutants**

Organic compound consists of carbon, hydrogen, oxygen, nitrogen and Sulphur. Organic compound emitted from sewage, urban waste water, industrial wastewater and agricultural waste. Example is Oleic acid, Palmitic acid, Dodecanoyl chloride and Docosanoic anhydride [12].

(b) **Inorganic Pollutants**

Developing countries are concerned about contamination of harmful chemicals such as nitrite, ammonium nitrate and heavy metals in drinking water. The high levels of inorganic nitrogen pollutants (nitrate, nitrite, ammonium) and inorganic phosphates in river water resulting from draining water from agricultural fields, releasing municipal/industrial sewage, etc. lead to many health problems. Nitrite is carcinogenic in nature, which increases the risk of stomach, liver and esophageal cancer and can lead to high levels of ammonium in the body [13].

(c) **Radioactive Pollutants**

Naturally radioactive material comes from earth crust and dissolves in surface drinking water. Anthropogenic radioactive material emitted from nuclear power plant, nuclear weapons testing and manufacture and application of radioactive material. Generally, radionuclide appeared in drinking water have series of uranium, thorium and aluminum and with naturally occurring materials of radium, uranium and the radioactive gas radon. These contaminants cause dangerous effect on human being. Radium causes bone cancer. Uranium also causes cancer in bone and toxic effect on kidney [7].

(d) **Suspended Solid**

Suspended solid are the pollutants municipal and industrial wastewater treatment plants and sewage treatment plants. There are three different types of suspended solid are found (a) sand and other material at washing steps (b) organic content that cannot used for final product (c) suspended solid in the wastewater [1].

(e) **Pathogens**

Pathogens are small microbes that cause disease, including bacteria, viruses, pillows, and certain parasites. Viruses generally present in wastewater are Hepatitis and Norwalk virus and a common fungus is Candida. A salmonella bacterium causes food poisoning whereas *Vibrio cholera* is the pathogen that causes cholera. Parasites such as Cryptosporidium and Schistosoma can cause diarrhea and all wastewater pathogens can lead to serious gastrointestinal illness [1].

(f) **Nutrients and Agricultural Pollutants**

As a result, the use of large quantities of chemical fertilizers in agriculture causes so many environmental problems as some fertilizers contain heavy metals (e.g. cadmium and chromium) and high radionuclide concentrations. Non-organic fertilizer contains salts of phosphate, nitrate, ammonium and potassium. Manufactured fertilizer industry contains excess heavy metals such as Hg, Cd, As, Pb, Cu, Ni, and Cu. Heavy metal fertilizer is deposited in the soil and plant system. Plants absorb fertilizers through the soil; they can enter the food chain that contaminates the water [11].

(g) **Thermal Pollution**

The temperature alteration in water bodies, as a result thermal pollution occurs. The thermal power plants discharge causes raise in temperature of aquatic system of 10 °C. Therefore, very serious effect on aquatic life due to global warms by thermal effect. Use of wind and solar energy in place of thermal energy. Thermal pollution decreases by plantation and reduce the emitting of carbon dioxide in environment [14].

6 Status of Ground Water

As we know that the groundwater is found beneath the surface water as it occupies fissures, pores, channels as well as other types of void spaces in the rock framework which are not filled with other materials like liquid hydrocarbons, solid mineral matters as well as various gases including air [2].

Globally the annual requirement of water is 6000–7000 km^3 and the globally reserve groundwater is about 7,000,000 km^3 [15]. Due to the pressure of the modern agriculture, urban lifestyle, industries the spread of contamination in water will doubles their speed and as a result cause many hazardous things like various types of diseases. In China's Northern provinces about 10 larger cities are using ground water which was a major concern in China [16]. Most of the sources of the private groundwater are located in the rural areas that are characterized by the ubiquity of animal as well as human contaminant sources with a lot of unregulated in the terms of treatment, design, location and maintenance and are associated with the low levels of institutional as well as consumer awareness [17].

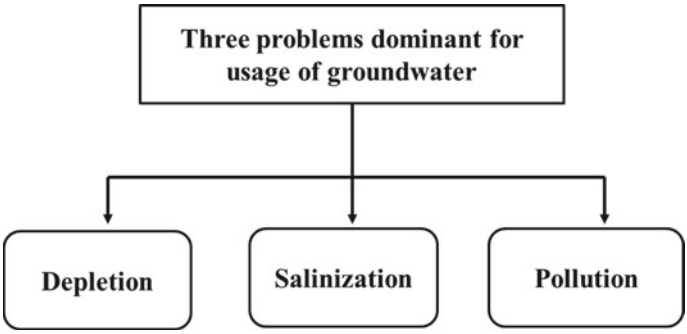

Fig. 4 Problems dominant during regular usage of groundwater

Figure 4 depicts the use of groundwater that are problem dominant like the depletion which are caused by over drafting as well as waterlogging, and salinization which are caused due to insufficient conjunctive use as well as due to inadequate drainage, and the third one is the pollution that are caused because of industrial, agricultural as well as the human activities [18]. In 2004, it was also found that the in North China Plain a sustainable groundwater resources were used for agriculture and was focusing on the major groundwater problems but a more process has to be done to utilize their groundwater. Many groundwater pilot projects were carried in country level and out of which Guantao is one of them. From about last 25 years China's institutional as well as legal framework was carried on the utilization of water resources [19]. Unlike the water which are present on surface or can say the surface water the groundwater is hard to measure, conceptualize but further it was analyzed in terms of timescale much longer than those of the analysis process used for the management of surface water [20]. According to the recent report on IWMI, it was stated that about 1.4 billion people's lives in the region where they face severe water scarcity within the first quarter of the next century [21].

7 Status of Surface Water

As we know that water occupies about 71% of earth surface and water is considered to be one of the scarcest commodities mainly in the developing countries and is one of the most demanding of all rural as well as urban amenities [22].

Figure 5 shows the toxic chemical production in India during the period of 1950–1987. It is observed that most of the pollutant released are from organic chemicals and petrochemicals and the rate of pollutants increases from 1960 to 1987 onwards.

According to the Water Framework Directive of European Union (WFD 2000), the Timia-Bega watersheds were selected a lot of watercourses, used for the

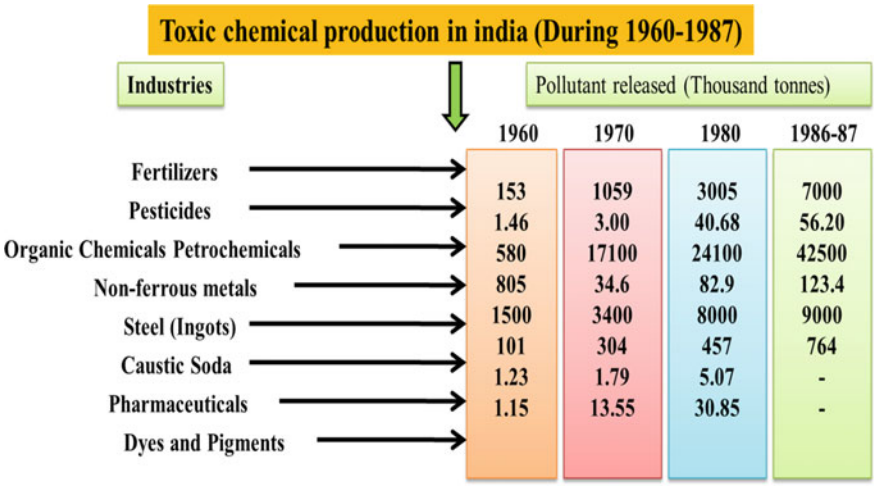

Fig. 5 Toxic Chemical production in India (1960–1987)

operational monitoring of the groundwater as well as for the surface water and are also responsible for the water quality determination and was found that 8 monitored ground water bodies, 3 surface reservoirs, 12 surface water bodies that are artificial as well as heavily modified and on the other side 14 surface water bodies found in natural status [23].

Figure 6 shows 7 models of the surface water with their versions and characteristics. The Streeter-Phelps provides the first S-P model in 1925. Mainly the S-P model focuses on the oxygen balance as well as the one-order decline of the demand for biological oxygen and is a one-dimensional stable-state model. USEPA

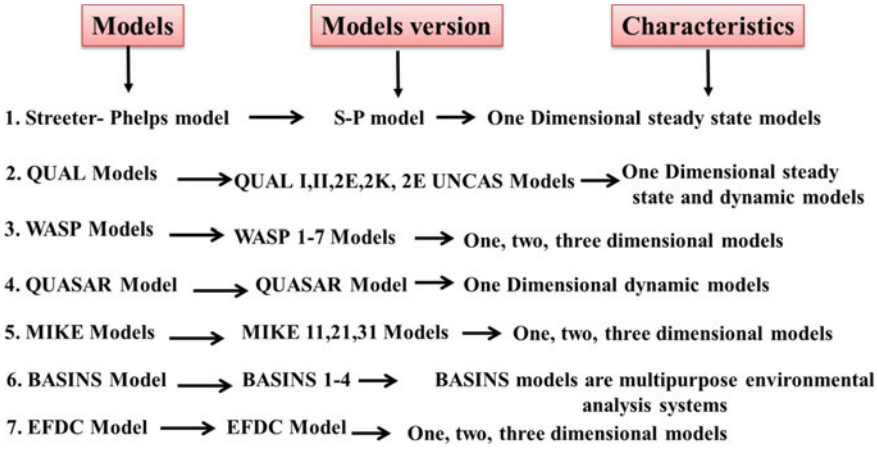

Fig. 6 Major surface water models with the model version as well as their characteristics

gave the model QUAL I in 1970. These models are suitable for both dendritic and non-point source pollution and are either a one-dimensional stable-state or dynamic model. USEPA developed a WASP model in 1983, and these models are appropriate for water simulation in lakes, rivers, coastal wetlands, estuaries, and reservoirs including one, two, and three-dimensional models. Whitehead provides model QUASAR in 1977 and is suitable for dissolving simulation of oxygen in larger rivers and is a one-dimensional dynamic model such as modes PC QUA SAR, QUESTOR and HERMES. The MIKE model has been developed by the Denmark Hydrology Institute that is suitable for simulating water quality in lakes, rivers, tidal wetlands, estuaries and is one, two or three-dimensional. In 1996, USEPA developed the BASINS model and these models are a multi-purpose environmental analysis system and are suitable for watershed-scale analysis of water quality and can also integrate non-point and point source pollution. Virginia Institute of Marine Science developed the EFDC model. USEPA listed this model as a water quality management tool in 1997 and these models are suitable for simulating water quality in estuaries, lakes, rivers, reservoirs and wetlands [24].

Table 2 Key issues, limitations and advantages regarding Large dam reservoirs, Small surface water reservoirs as well as Groundwater storage [25]

	Large dam reservoirs	Small surface water reservoirs	Groundwater storage
Key issues	• Sedimentation • Dam safety • Environmental impact • Social impacts	• Environmental impacts • Adequate design • Dam safety • Sedimentation	• Groundwater Salinization • Rising water levels • Groundwater pollution • Management of access and use
Advantages	• Multipurpose • Large • Reliable yield • Carryover capacity • Low cost per m^3 water stored • Flood control hydropower Groundwater recharge	• Groundwater recharge • Multiple use • Ease of operation • Responsive to rainfall	• Water quality • Operational efficiency • Little evaporation loss • Ubiquitous distribution • Available on demand
Limitations	• Sedimentation • Environmental impacts • Social impacts • Dam safety	• Environmental impacts • Adequate design • Dam safety • Sedimentation	• Groundwater salinization • Rising water levels • Management of access and use • Declining water levels • Groundwater pollution

Table 2 depicts the major advantages, issues as well as the limitations of large dam reservoirs, Small surface water reservoirs as well as Groundwater storage in which groundwater were used for further uses. In groundwater storage the water were used to store in underground aquifers and with an advantage that groundwater can be stored for a year and is also purified of biological pollutants due to the slowly percolations of water into aquifers. On the other side small reservoirs are considered to be operationally efficient and flexible in use. And the last one is the large reservoirs have great yield related to the small reservoirs [25]. Groundwater is considered to be India's most vulnerable as well valuable resource as groundwater is a major source of drinking water for various rural communities as well as for cities communities [26]. In 1998, about 43.57 million hectare-meters per year is the estimated total replenishable groundwater resource in India [27].

8 Conclusion

Are we not aware of the various problems that occur in our nature, particularly in different water bodies? The causes of our undisciplined actions and irresponsibility are water pollution. We, humans, only create problems that we will bear the burden of these problems as well. We all know that water pollution can have a serious and serious impact on our health. It can cause such diseases and sicknesses that will have a serious impact on our health. We all know that water is so important. Water is our body's essential. Without water, neither we nor any living thing can survive. So, we should keep, protect, save, and help prevent pollution of our waters, we should act as early as now, we should save rivers, seas, and oceans, and other bodies of water, because we will bear the burden of this problem as well. We should not wait until people compete to get enough, fresh and clean water, the time when clean water is insufficient for humans and animals, and the time when our water sources are diminishing or when there are absolutely no water sources. And so, let's be disciplined and responsible enough to save, protect and preserve not only water sources but also our mother nature because our nature provides and helps us in our everyday lives. It's our only living source. Let's not destroy it or contaminate it. Let's take action for a change. We need and should help to save and preserve the nature of our mother, especially the various water bodies. Absolutely, in how we can help there are many simple ways. Change before we make changes in our nature.

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