MJSAT

Malaysian Journal of Science and Advanced Technology

journal homepage: https://mjsat.com.my/

Causes and Impact of Industrial Effluents on Receiving Water Bodies: A Review

Sarwat Jahan *[1], and Ajay Singh[2]

[1]*Department of Zoology and Environmental Science, Natural Product Laboratory, Deen Dayal Upadhayaya Gorakhpur University. Gorakhpur, Uttar Pradesh, India.*

KEYWORDS

Industrial effluents
Industrialization
Ami River
Water pollution
Aquatic ecosystem

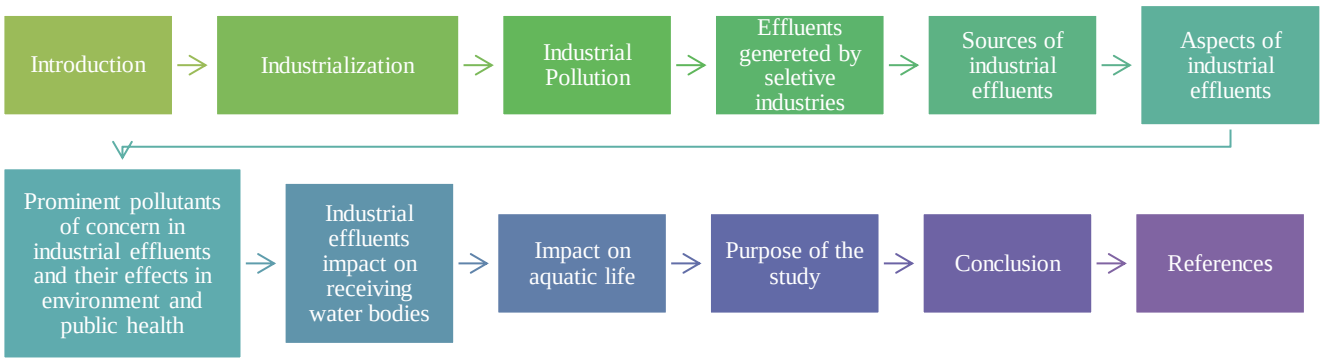
ARTICLE HISTORY

Received 18 February 2023
Received in revised form 12 April 2023
Accepted 21 May 2023
Available online 27 May 2023

ABSTRACT

Industrial development has begun to have a negative impact on the entire environment. The constant need and agreed of humans has resulted in the formation of massive polluting industries. Manufacturing, chemical and fertilizer industries are among those that are depleting the earth's resources while also putting enormous strain on the environment and ecological system. Water pollution is well-known to be a growing problem of 21st century all over the earth. The planet's natural diversity is affect seriously by any human activity. Rapid industrialization is an index of development of a nation, however; a rising in population growth alters it unfavorably. India, a developing nation has a challenge of maintaining a balance between these and the environment. In India, there has been a rapid growth in industrialization after freedom. The aims of this review paper represent the link between industrial effluents and define sources of water pollution present development in the research on the fresh water aquatic ecosystems.

MIND MAP OF REVIEW PAPER



1. INTRODUCTION

Eonomic growth has been regarded as the primary driver of global growth since the days of the industrial and technological revolutions. Industrial pollution has become a major concern for organizations attempting to combat environmental degradation. If we study of primitive history, we find that most of developed and famous historical cities develop near bank of river because requirement of water for

*Corresponding author:
E-mail address: Sarwat Jahan <sarwatj1995@gmail.com >.
https://doi.org/10.56532/mjsat.v3i2.144
2785-8901/

stay alive. Humans are completely depended on water for different types of activities. But due to globalization and industrialization, the requirement of water for their functioning activities and therefore contamination of surface water and groundwater also increase. Increases pollution of water raises a question mark on existence of life. After organization of industrialization, rapidly increase pollution into river water. The people using river water for long time, after river water polluted suddenly moves to use of groundwater. Now everybody were depends on groundwater and complete their all requirements, polluted water bodies lose the visual nature. No, any substitute matters are available which can alternate with water. These industrial effluents clutch a wide range of pollutants. Viz, petroleum hydrocarbon, chlorinated hydrocarbon and heavy meats, various acids, alkalies, dyes and other chemicals that greatly alter the water quality. These wastes will create water pollution if they are released into aquatic habitats without being adequately treated, [1]. Arsenic, cadmium, and chromium are vital pollutants discharged in wastewater, and the industrial sector is a significant contributor to harmful pollutants [2].

2. INDUSTRIALIZATION

Industrialization is the social and economic revolution of a human being from an agricultural to an industrial land. Aspect of a lager modernization process in which social revolutionize and economic progress are inextricably correlated to technological modernization. Exclusive economic organization for manufacturing. Industrial expansion plays a key role in economic development of a nation. Industrial development is compulsory for transformation of agriculture since chemical fertilizers, pesticides, herbicides etc. are all industrial goods that are crucial to enhance the production and also, it uplifts the evolution of science and technology. Severe lack of capital is the primary issue of Indian economy. With the support of obvious and hub wealth, industry can acquire enhanced profit that can be rejuvenated for development and growth. Industrialization aids in the advancement of trade.Industrialization causes water pollution. Water pollution mostly comes from five different sources:–Sewage, 2.Agricultural –Run -off, 3. Industrial Effluents, 4. Septic Tank Waste, and Septic and, 5. Storm water runoff. Industrial water pollution is bring on by the discharge of hazardous chemicals and other substances into water, rendering it flabby for drinking and other uses. Although 70% of the planet is covered in water, only bodies of water like lakes, ponds, rivers, reservoirs, and streams are essential for our existence as well as the survival of all other types of life. Industrialization, agricultural production, and metropolitan life have resulted in the dreadful conditions and contamination of the environment, negatively disturbing the water bodies, (rivers and oceans) essential for life, ultimately disturbing human health and sustainable social growth [3]. Industrialization impact show in figure (1).

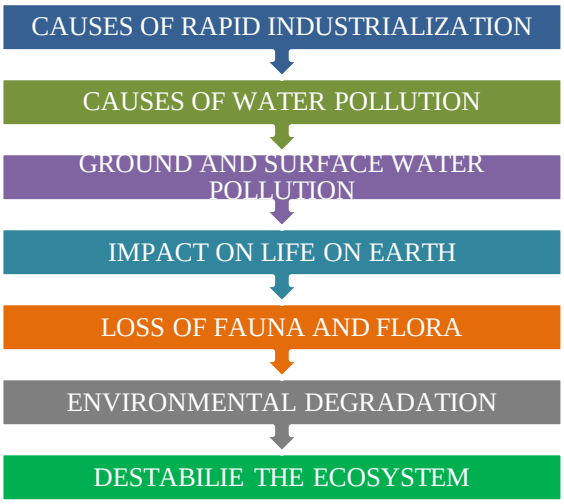


Fig.1. Impact of rapid industrialization on environment

3. INDUSTRIAL POLLUTION

Humans were able to advance further into the 21st century with the advent of the industrial revolution. Technology advanced quickly, science advanced, and the manufacturing age dawned. Individual pollution was introduced as a result of all of these changes. Previously, industries were small factories that polluted the environment primarily with smoke. However, because the number of factories was limited, and they only worked a limited number of hours per day, pollution levels did not rise significantly. However, when these factories are scaled up to become industries and manufacturing units. The issue of industrial pollution becomes more prominent. Industrial pollution is any type of pollution that can be traced back to industrial practices. The majority of global pollution can be traced back to industries of some kind.

4. INDUSTRIAL EFFLUENTS

Industrial effluents are liquid wastes produced during industrial processes. In India, rapid industrial development has resulted in a serious waste disposal problem. It is the major source of natural water pollution because the majority of it is discharged into nearby river sources. This increases the pressure on wastewater management and can eventually lead to a point sources pollution concern, which not only worsens environmental pollution but also poses serious health risks.

5. SOURCES OF INDUSTRIAL EFFLUENTS

The effluents of the industries give a great deal of influence on the pollution of the water bodies, these effluents can alter the physical, chemical and biological nature of the receiving water body [4]. Show in figure (5).

5.1 Sugar industry effluents

Uttar Pradesh is the traditional producer of sugar and has the second rank with approximately 105 sugar industry producing more or less 1.1 million tons of sugar annually out of total 380 factories distributed in India producing 4.1 million tons of sugar produces annually [5]. Saraya sugar mill Sardar Nagar, Gorakhpur, major product, sugar mill also generates various by products which cause significant impact on the environment. Sugar mill generates in various steps release

molasses, alcohol, many by – products and liquid wastes and major pollutants for the local rivers and lakes [6-7]. In India, use of phosphoric acid and sulfur dioxide through clearing of sugar cane juice is the main reason for the incidence of algal bloom which subsequently colors this dark and increase BOD, COD, Suspended solids(SS), unpleasant odor and heavy metals (Fe, Cu, Zn, Mn, Pb)[8]. High value of COD indicators, the high organic load due to recalcitrance of chemicals that have escaped biodegradation [9]. Further, these heavy metals present in aquatic ecosystem may accumulate fish and enter into human metabolism through their consumption and results in bioaccumulation [10].

5.2 Paper and Pulp industrial effluents as sources of pollution

Paper and pulp waste is serving threat to aquatic life because its effluents characteristically contain very high COD, BOD and strong color [11]. The presence of lignin in the waste, which is derived from raw cellulose material and is not easily biodegradable, makes the COD/BOD ratio of the waste very high. The effluents contain a high concentration of suspended particulate material. [12]. Paper and pulp industry effluents are fatty acids and resin acids are toxic compound (fig.2). In particular, resin acid is considered the major factors in the toxicity of these effluents [13-14]. Chlorinated Complexed by products like Trichlorophenol, Trichloroguicol, Dichlorophenol, Dichloroguicol, pentachlorophenol, Dibenjo-p-dioxin and Benzofuran became the main components of the effluents [15-16]. Which are responsible for higher biological and chemical oxygen demand (COD) [17]. Out of which dioxin accumulate in fatty tissue of animals exposed to paper mill effluents creating and reached to humans by food chain and causes reproductive and developmental problems, damage the immune system, interfere through hormones and also lead to cancer [18]. A high value of physic-chemical parameters like color, pH, suspended solid, BOD, and cod in the treated effluent as per Indian standards was observed by Bhatnagar [19]. Similar findings by other workers corroborate the cause of pollution of aquatic bodies due to paper and Kraft mill effluents, [20, and 21].

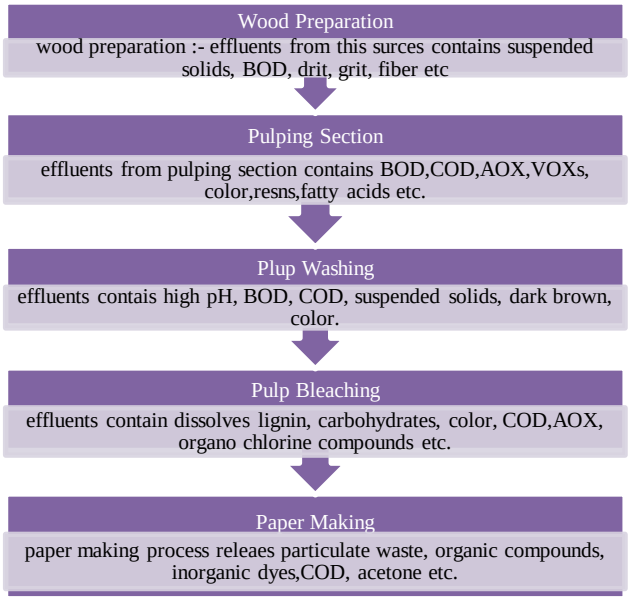


Fig. 2.Paper and Pulp industrial bleaching effluents

5.3 Chemical fertilizer industrial effluents

India is the world's second- largest consumer of fertilizer, followed by china. The Indian fertilizer industry meets 80 percent of its urea fertilizer needs [22]. Effluents from fertilizer industry contain highly toxic chemicals that may pollute the aquatic environment adversely. The nitrogen fertilizer effluents have been considered as serious pollutants as it has heavy metals, ammonia, urea, high pH and low DO [23]. Groundwater contamination by nitrate is a growing problem throughout the world due to intensive use of fertilizers in agricultural [24]. Causes several health disorders namely, Methaemoglobinemia, gastric cancer, goiters, birth malformations hypertension, etc. [25]. According to Sundaramoorthy and his co-workers [26], fertilizer industry is one of the major water consuming industry and responsible for water and soil contamination adequately. Ammonia is the main ingredient of fertilizer exists in two interchangeable forms in water, i.e. unionized ammonia (more toxic) and ammonia ions (less toxic) and their ratio can be controlled by pH and temperature [27]. Heavy metals and other dissolved contaminants have been identified by EPA 2000 [28] as primary toxicant, i.e. these are persistent, bioaccumulative, and toxic. An investigation of the effluent of a fertilizer industry in Sultanpur, Uttar Pradesh showed comparable results to the same from other places. It was reported that the light-brown effluents had higher pH, EC, COD, TDS, nitrogen, phosphate, sulfate content, and low level of dissolved oxygen and presence of heavy metals [29]. These results indicate that waste containing hydroxyl and Chlorosubstituted derivatives of benzene may pose a greater toxicity problem to micro biota than wastes containing methyl- substituted derivatives. The nitrification stage of the nitrogen cycle will also be greatly impaired in the presence of these groups of chemicals in a river [30].

5.4 Textile industrial effluents

In India, textile industry is considered as important sources of income as well as cause of pollution; during series of processes it consumes and generates ample quantity of water/effluents (containing dyes, heavy metals, organic and inorganic wastes), fuel and variety of chemicals [31]. It was observed that the textile effluents deteriorates the quality of receiving medium and impose threat to inhabitants [32]. Manikandan et al. [33] has reported that textile industry effluents discharge was turbid and colored, loaded with organic and inorganic constituents, hardness (due to higher concentration of sulfate, chloride calcium and magnesium), alkalinity, pH, conductivity and low BOD (Biological Oxygen Demand)/COD (Chemical Oxygen Demand) ratio which indicate the existence of large quantity of non-biodegradable organic matter being inappropriate for direct discharge in water bodies without treatment. Similar reports also suggested that the values of most Hydrobiologcal parameters were higher than the permissible ranges in drinking water, there by rendering the aquatic bodies polluted and unfit for agriculture, [34]. Industrial activities like electroplating, metal cleaning and dyeing processing, cement, and leather tanning are the major sources for releasing chromium (particularly chromium sulfate) and aromatic amines into the environment, having carcinogenic effect on human health [35]. The effluent handling in textile industry involves the elimination of suspended solids and the reduction of the effluent quality using methods like screening, sedimentation, neutralization, Mechanical flocculation, and chemical coagulation [36].

Sources of hazardous effects to environment associated with textile dyeing (fig.3).

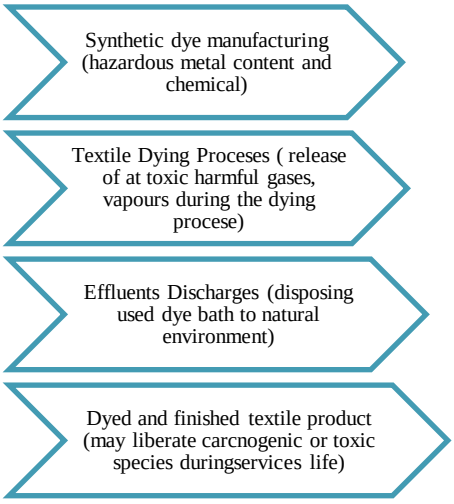


Fig. 3. Possible Sources of hazardous effects to environment associated with textile dyeing

5.5 Pharmaceutical effluents

The pharmaceutical industry in India is the world's third-largest in terms of volume and stands 14th rank in terms disposes off their effluents into the streams either directly or after partial treatment [37]. Several pharmaceuticals production facilities were found to be sources of much higher environmental concentrations than those caused by the applications of drugs [38]. Trace number of pharmaceuticals in drinking water for longer duration may cause considerable adverse effects to human health and aquatic life, [39]. Pharmaceutical is one of the major industries that pollute the water bodies in large amount as they use about 99% of water for the production of recipients. The water released from this industry is generally from drug manufacturing area that consists of various toxic elements that are injurious for both human and animals (fig 4). Different treatment methods such as coagulation, reverse osmosis, flocculation, and membrane filtration, are useful to reduce the existence of elements like BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), TSS (Total Suspended Solids), and TDS (Total Dissolved Solids) from the effluent [40].

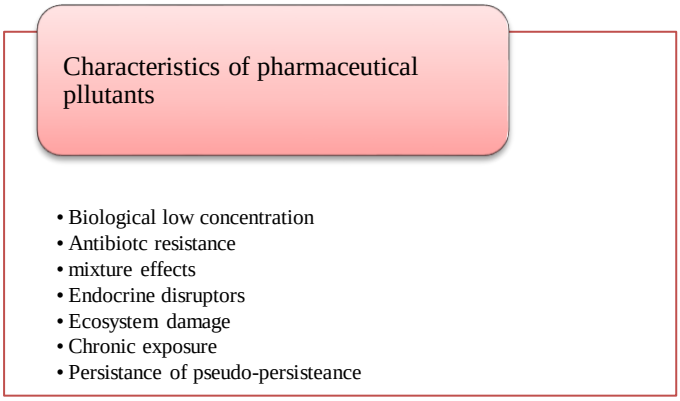


Fig. 4. Pharmaceutical effluents consists of various toxic elements that are injurious for both human and animals

Table 1. Updated Status of Common Effluent Treatment Plants (CETPs) in Ganga Mainstream (2020-21) [82] [83].

CETP Name/ District	Coordinates (Lat/Long)	Installed Capacity (MLD)	Utilized capacity (MLD)	Type of Units (Operational member Units)*	Technology	Compliance status/ date of monitoring
Compliance status/ date of monitoring	26.417256, 80.421362	36 (09 industrial + 27 sewage)	34.35	Tannery (345)	UASB	**Latest inspection: 12.03.2021 Compliance status:** Non complying W.R.T. TSS (135 mg/l compared to norm of-100 mg/l), BOD (160 mg/l compared to norm of- 30 mg/l), COD (672 mg/l compared to norm of-250 mg/l) and sulfide (37.76 mg/l compared to norm-2 mg/l).
CETP, Site-II, Unnao Unnao City, UP	26.559445, 80.513877	2.15	0.56-0.998 (February, 2021) and 0.64-0.997 (March, 2021)	Tannery (15)	ASP with Extended aeration	**Latest inspection: 15.03.2021 Compliance status**: Non complying W.R.T. Sulfide (11.52 mg/l compared to norm-2 mg/l) and Oil & Grease (18.5 mg/l compared to norm-10 mg/l)
CETP, Banthar Unnao, UP	26.483555, 80.460844	**4.5**	22.06-30.67 (01.03.2021 to 14.03.2021)	Tannery (27)	ASP with Extended aeration	**Latest inspection: 15.03.2021 Compliance status: Non complying** W.R.T. chloride (3200 mg/l compared to norm-1000 mg/l), sulfide (30.08 mg/l compared to norm-2 mg/l), COD (560 mg/l against norm-250 mg/l) and BOD (950 mg/l compared to 140 mg/l)

CETP, Pantnagar (SIDCUL) US Nagar, UK	28.994201 , 79.412901	4.0	1.3-2.1	Mixed type industries (300)	ASP	**Latest inspection: 23.03.2021** **Compliance status: Complying**
CETP SIDCUL, Haridwar, UK	29.947136 , 78.080008	5.2	4.5	Mixed type industries (511)	MBBR & extended aeration system	**Latest inspection: 17.03.2021** **Compliance status:** Non complying W.R.T. BOD (64 mg/l against norm-30 mg/l)
CETP, Sitarganj US Nagar, UK	29.026727 , 79.693992	3.8 (as per consent)	1.3-1.9	Mixed type industries (agro based and engineering) (67)	ASP	**Latest inspection: 22.03.2021** **Compliance status:** Non complying W.R.T. Ammoniacal Nitrogen-66 mg/l (against norm-50 mg/l) and Cyanide- 0.28mg/l (against norm-0.2 mg/l)
CETP, Rooma Kanpur, UP	26.366985 , 80.425640	1.55	0.489 (February, 2021)	Textile (11 operational)	ASP	**Latest inspection: 04.03.2021** **Compliance status:** Non complying W.R.T. BOD (88 mg/l against norm-30 mg/l), COD (352 mg/l against norm- 250 mg/l), FDS (5388 mg/l against norm-2100 mg/l) and sulfide (124 mg/l againstnorm-2 mg/l)
CETP, Pilakhuwa Hapur, UP	28.700674 , 77.672084	2.1	1	Textile (30 operational)	ASP	**Latest inspection: 22.03.2021** **Compliance status:** Non complying W.R.T. TSS-108 mg/l (against norm-100 mg/l), BOD-107 mg/l (against norm-30 mg/l), COD (382 mg/l (against norm-250 mg/l), FDS-2616 mg/l (against norm-2100 mg/l), Nitrate-19.3 mg/l (against norm-10 mg/l), Ammoniacal Nitrogen- 95 mg/l (against norm-50 mg/l), and Iron-3.63 mg/l (against norm-3 mg/l)

Table 2. State-wise STP Status and Sewage generation in front towns of Ganga CPCB 2020 [82].

State	Approx. Sewage Generation in Ganga front Towns (MLD)	Towns Covered	Total STPs (Sewage Treatment Plan Installed) monitored	Installed capacity of monitored STP (Sewage Treatment Plant) (MLD)	Operational Capacity (MLD)	Utilized Capacity (MLD)	Nonoperational Capacity (MLD)
Uttarakhand	239.8	16	49	344.64	336.32	226.62	8.3
Uttar Pradesh	1,255.2	10	30	1,137.76	1,080.1	814.67	57.7
Bihar	480.0	01	05	205	160	64	45
Jharkhand	12.0	01	02	12	12	07	00
West Bengal	1,571.5	22	34	535.67	226.99	185.22	308.68
Total	**3,558.5**	**50**	**120**	**2,235.07**	**1,815.41**	**1,297.51**	**419.68**

Type of Waste	• Types of Plants
Oxygen - Consuming	• Breweries, Dairies,distillers, Packing Houses, Plup and Paper, Tanneries, Textiles
High Suspended Solids	• Chemical Plant, Coal Washeries, Iron and Steel Industries,palm Oil Mills
Oily and Grease	• Laundries.Metal Finishing,oil Fields,petroleum Rifineries,tanaries,palm Oil Mils
Colour	• Plup And Paper Mills,tanneries,textile Dye Houses,palm Oil Mills
High Acid	• Chemical Plants,coal Mines,iron And Steel
High Alkaline	• Chemical plants, tanneries,laundries,textile finishing m
High Temperature	• Bottle washing plants,laundries,power plant,textile

Fig. 5. Industrial effluents generated by selected industries.

6. Aspects of Industrial Effluent

Wastewater contains several pollutants and toxins which are considered as most serious risk to the ecosystem and public health. In worldwide wastewater is characterized as: (i) Physical: pH, Temperature, turbidity, total suspended solids (TSS), color, odor (ii) Chemical: COD (Chemical Oxygen Demand), TOC (Total Organic Carbon), heavy metals, Dissolved Oxygen (DO), toxic substances, phosphorus, chlorides, sulfur and other trace elements (iii) Biological: BOD (Biological Oxygen Demand), microbes like viruses, bacteria, parasites, oxygen necessary for nitrification and microbial population [49]. Upon releasing the water containing these impurities into surface, ground and seawater, there occurs nutrient depletion, disorderliness of water quality, and bringing down the DO (Dissolve Oxygen) content which in turn affects the aquatic ecosystem. Feed and produced water quality, and production method mainly determines the aspect, quality, composition, and quantity of the effluent, which in turn influences the cost of effluent disposal and treatment methods. Toxins of wastewater could be either organic (aromatic hydrocarbons, phenols pesticides, phenols, etc.), inorganic (nitrogen, sulfur, phosphorus, chlorides, heavy metals such as, Hg, Pb, Cd, Zn, Ag, Ni etc.), radioactive (nuclear material); according to which pre-treatment and post-treatment methods are implemented. Moreover, other industrial effluents such as manufacture of cement, cannery, metal containers, synthetic resins and polymer, soft drinks, soap and detergent, viscous rayon, gelatin, explosives, bleach-liquid, dye, asbestos, chlor-alkali, metal-pickling, coffee-pulping, slaughterhouse, meat-pickling, etc., contributes in environmental contamination in adding to the main industrial wastewater. Therefore, in order to protect the ecosystem and the general public's health, effluent treatment method must adhere to the terms of regulations the characteristics of the effluent that is discharged in water streams.

7. Prominent Pollutants of Concern in Industrial Effluent and Their Effects in Environment and Public Health

The main contaminants in industrial wastewater are nitrogen, phosphorus, hydrocarbons, heavy metals and microbes. Industries producing hazardous effluents (fig.6)

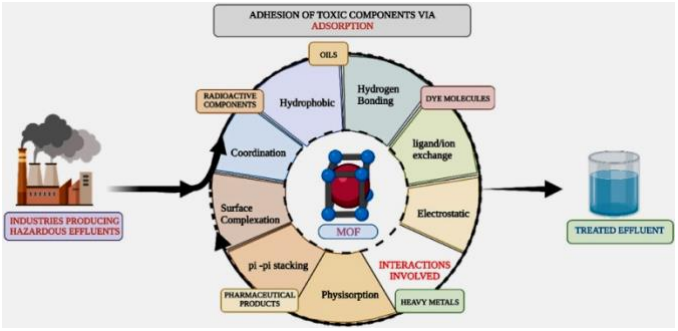


Fig. 6. Industries producing hazardous effluents (Saravankumar et al. 2022)[84].

7.1 Nitrogen and phosphorus

Ammonia is generally present in wastewater, which is the predominant form of nitrogen, is known to be toxic. The intake of nitrate containing water could lead to methemoglobinemia, also called as blue baby's syndrome, in infants and other susceptible individuals [41]. Phosphorus is considered as one of the main eutrophic nutrient which has an impact on accelerating the chlorine content essential for disinfection of water bodies, which could increase the risk of cancer and leads to the stimulation of negative microbes such as P. fisteria which causes eye and respiratory irritation.

7.2 Hydrocarbons

The existence of hydrocarbon pollutants in wastewater effluents leads to negative effects on the environmental and human health impacts such as threat to fisheries, marine wildlife habitats, human health, and leads to destruction of the ecological balance [42].

7.3 Heavy metals

Heavy metals present in the effluent have a bent of binding with proteins, thus changing their confirmation and inactivating them, which often results in public health's complications such as skin irritations, vomiting, nausea, anemia, upsetting protein metabolism, etc.,[43]. Heavy metals like zinc, copper, nickel, arsenic,(heavy metals contamination show in fig. 7) etc., are known for their toxicity, even at particularly low concentrations, and as a result, they cause negative threat to human health and flora and fauna of receiving aqueous bodies. There is a correlation between arsenic concentrations in biological samples (hair and blood) from patients with skin diseases and intake of arsenic contaminated drinking water [44]. Another Bangladesh study showed that many people suffer from scabies due to river pollution [45]. Not only that, but water pollution from industry can also cause skin cancer [46]. Lead is metallic element that can be hazardous to one's health and the environment. Because it is a non-biodegradable substance, it is difficult to remove once the environment has been contaminated. Mercury is harmful to the health of animals as it can cause illness through mercury poisoning. Minamata is well known case of mercury poisoning in japan.

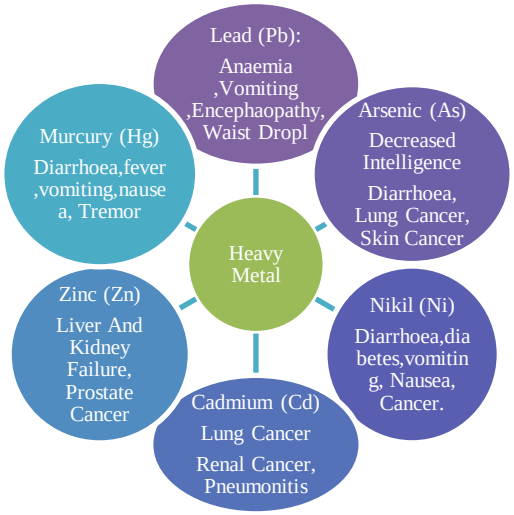


Fig. 7. Heavy metals contamination

7.4 Microbes

The main pathogenic protozoans found in the industrial wastewater are Giardia and Cryptosporidium that have the capability to cause acute and chronic diseases with short-term and Long-term effects, like degenerative heart diseases and stomach ulcers with harshness. Consequently, due to large-scale industrialization and enhance in population density, the society is dealing with problem regarding wastewater management. The effluent generated due to industrial activities comprises a major cause of pollution, which are great implications on water quality management. Moreover, the risk of non-biodegradable and intractable pollutants in water is their possible to survive in natural ecosystems for a prolonged period and have their capability to accumulate in successive levels of natural food chain. Considering the mentioned critical impacts, selection of treatment processes is necessary for the wastewater effluent prior to being discharged into the environment. Nitrate contamination in drinking water may cause goiter in children [47]. A case from Changhua County, Taiwan also showed that high levels of chromium pollution were associated with gastric cancer incidence [48]. Pollution exposure experienced by children during critical periods of development are associated with height loss in adulthood [50].

7.5 Asbestos

This pollutant is carcinogenic and poses a serious health risk. Asbestos fibers can be inhaling and cause a risk of developing asbestosis (fig .8), mesothelioma, lung cancer, intestinal cancer and liver cancer. A study based on changes in water quality in the watershed showed that a grade 6 deterioration in water quality resulted in a 9.3% increase in deaths from digestive cancer [51]. The strength of industrial organic water pollution is positively associated with infant mortality and child mortality in less developed nations, and industrial water pollution is a major cause of infant and child mortality in these less developed nations [52].

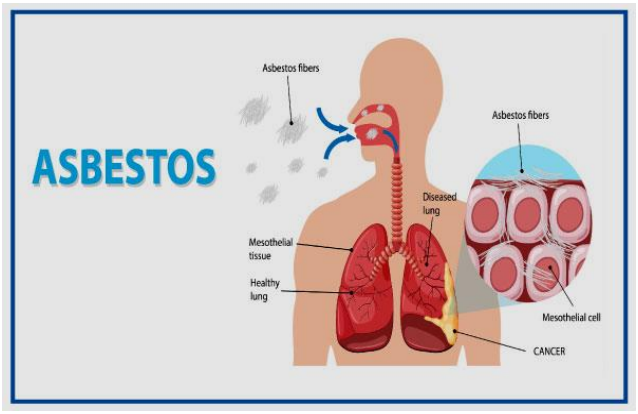


Fig. 8. Developing asbestosis in lung.

8. INDUSTRIAL EFFLUENTS IMPACT ON RECEIVING WATER BODIES

Consequence of urbanization on water quality is result by a long-term monitoring and study of fecal coliform in stream water-quality in the city of Atlanta [53]. Organic pollutants and heavy metals are the main source of pollutants in the river [54]. There is a close relationship between chemical oxygen demand (COD) and water and dissolved oxygen (DO) act as an indicator of water pollution [55]. Major source of river water pollution are organic pollutants and runoff from agricultural waste [56]. Main cause of Gomati river pollution is domestic waste [57]. The Most polluted river in India is Yamuna River and many industries are located on the bank of rivers [58]. Son river water pollution generally occurred by paper mill effluents and thermal power plant and effluents) [59]. Mula river pollution was reported by Sahu [60]. Due to municipal effluents, industrial effluents, agricultural run-off water quality is deteriorating in the river [61]. Sewage treatment plants are unable to operate properly, and it is the main risk to river water quality [62]. River pollution affects food web and hampers public health [63]. Industrial effluents characteristics provide information about the aquatic habitat within such rivers and streams into which they are discharged. Most of these effluents cause great destruction, to which the microbial creature is the most unfavorably affected. Changes in the characteristics of water may have serious impact on aquaculture, fisheries and agricultural production and human use are evident in the plain regions of the rivers, and hence they are more vulnerable getting influenced [64], [65] and [66]. “Status of water quality in India [67]. Discharge, Brahmaputra River is the largest river in the world and in Tibet; this river is known as [68].

Table 3. Priority wise number of polluted Indian River stretches

Priority category	Health status	BOD Value (mg/l)	Number of stretches
1	Severely polluted	BOD>30 mg/l	45
2	Moderately polluted	BOD, 20-30 mg/l	16
3	Moderately polluted	BOD, 20-10 mg/l	43
4	Mildly polluted	BOD 6-10 mg/l	72
5	clean	BOD 3-6 mg/l	175
Total			**351**

*Data sources CPCB 2018 [81].

9. Impact on Aquatic Life

The aquatic ecosystem depends on the natural calamity of the water bodies. Industrial effluents agricultural activities, urban waste management issues, increase in urbanization[69]. Aquatic environment are pickers for anthropogenic contamination and industrial wastes and leaks, where chemicals or solid pollutant.[70]. Phosphorus and nitrates from fertilizers are detergents contaminate surface waters where they act as nutrients and encourage the growth of oxygen consuming algae which decrease the DO levels of water, killing fish and other aquatic organisms [71]. Industrial effluents result in the accumulation of poisonous chemicals such as Arsenic, mercury, cadmium, lead etc., which kill aquatic organisms and capable of reach human body through contaminated food(i.e., fishes etc.) [72]. Domestic, commercial and industrial effluents (petroleum refineries, paper mills, breweries, tanneries, slaughterhouses) contaminate the water with organic pollutants. These provide nutrition for microorganisms which decompose the organic matter and consume oxygen and decrease the DO level of the aquatic organism thereby kill the aquatic organisms.[73].Thermal pollution of water drop off the DO level of the aquatic life form making it incapable of sustaining of life. Oil pollutants have been known to be responsible for the birds and fishes [74]. Phytoplankton play an significant and exceptional role of indicators and pollution purifiers, through participating in material cycle and energy flow in streams [75]. Large number can cause the depletion of oxygen in the water, which will lead to mass mortality of fishes [76]. Temperature is a significant aspect of water biodiversity. They play a key and irreplaceable role of indicators and pollution purifiers, through participating in material cycle and energy flow in lakes [77]. Occurrence and reduces the recreational value of surface water, which can mar the water contact sports activities. Their great number can cause the depletion of oxygen in the water, which will lead to mass mortality of fishes[78]. The occurrence of rich algal flora results generally at the place where are high levels of nutrients, together with favorable environmental situation [79]. Impact of industrial effluents in marine, land, food chain, water cycle show in (fig.9).

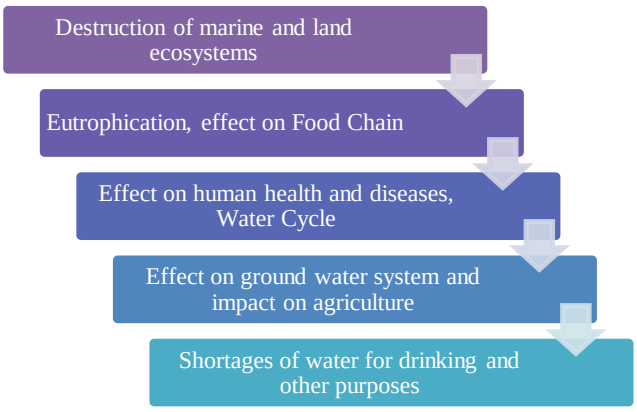


Fig. 9. Impact of industrial effluents

10. Urban Industrial Effluents as a Growing Global Challenge

Several global studies have been conducted recently to calculate the amounts of wastewater and provide projections for the future. Qadir et al. [80] calculated the 380 billion m3 of wastewater was produced worldwide each year. The amount of daily wastewater created is anticipated to rise by 24% (470 billion m3) by the end of the era in 2030 and by 51% (574 billion m3) by 2050 based on the rate of population expansion and urbanization (fig.10). It should be mentioned that Asia produced the most wastewater globally, accounting for 42% (159 billion m3) of the total amount produced worldwide. It is predicted that wastewater generation will increase to 44% by 2030, by 2030, necessitating care.

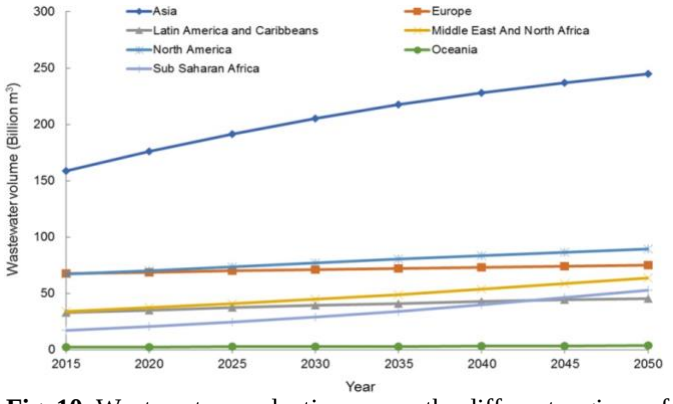


Fig. 10. Wastewater production across the different regions of the world for 2015-2050 (Source: Qadir et al., 2020)

11. Purpose of this Study

This study scientifically analyzed the impact of industrial effluents on receiving water bodies, aquatic life and human health and the outlook of different diseases, focusing on a complete review of the relationship, system and influencing factors of water bodies. From the point of view of limitations, aim of this paper mostly focuses on the research of environmental science.

12. Conclusion

Discharges of industrial effluents into a receiving River in India regularly result in the presence of India high concentrations of pollutants in the water and sediment. The pollutants include shown to be present in concentratins, which can be lethal to different organisms. The effluents also have major harmful effects on the water quality of the receiving water bodies and such as, they are rendered not good for human use. Government of India has made it mandatory to treat the effluents before release, non-compliance draws heavy punishment. All such industries are expected to fit a wastewater treatment plant/ unit so that the pollution due to discharge of slude/effluents be minimized if not comletely closed. Aim of the this literature revies is as follows-recommendations

- Furthermore, it is found that, the situation is getting worse every day as a result of industry's lack of true and serious approach to the treatment and disposal of industrial wastewater.

- To address industries, stronger legislation needs to be implemented.
- Serious penalties for such industries are needed.
- Industries should be forced to build treatment and held accountable for adhering to the rules established for their activities.
- It is important to raise public understanding of the harm such actions can do the environment and human health.

ACKNOWLEDGEMENT

Authors are appreciative to the supervisor (Prof Ajay Singh) assistance during the current literature review study.

CONFLICT OF INTEREST

The authors have declared that they have no conflicts of interest that are relevant to the content of this literature review.

REFERENCES

[1] Chowdhary, P., Bharagava, R. N., Mishra, S., and Khan, N., "Role of Industries in Water Scarcity and its Adverse Effects on Environment and Human Health". Environ. Concerns Sustain. Dev., 235–256, 2020, doi:10.1007/978- 981-13-5889-0_12

[2] Chen, B., Wang, M., Duan, M.,Ma, X.,Hong, J., Xie, F., et al. In Search of Key: "Protecting Human Health and the Ecosystem from Water Pollution in China". J. Clean. Prod., 228, 101–111, 2019,doi:10.1016/j.jclepro.2019.04.228

[3] Xu, X., Yang, H., and Li, C. "Theoretical Model and Actual Characteristics of Air Pollution Affecting Health Cost: A Review". Ijerph., 2022a, 19, 3532. doi:10.3390/ ijerph19063532

[4] A. N. Moses, N.N Destaings, N.E. Masin Deandj.Miima , "Effluent Discharge By Mumias Sugar Company In Kenya: An Empirical Investigation of The Pollution of River Nzoia Sacha", Jounal of Environmental Studies, pp 1-30, 2010.

[5] A.R . Memon, S.A Soomroand A.K . Ansari, "Sugar Industry Effluent-Characteristics and Chemical Analysis", Journal Of Applied Environmental Sciences, vol 1 , number 2, pp 152-157,2006.

[6] N. Manivasakam, "Industrial effluents origin, characteristics, effects, analysis and treatment", Sakthi Publications, Kovaipudur, Coimbatore, India.1987.

[7] S. Samuelands M.Muthukkaruppam, "Physico-chemical analysis ofsugar mill effluents, contaminated soil and its effects on seed germination of paddy (Oryza Sativa L.)", Archives of lnternational Journal of Pharmacology and Biology , vol , number 5, Pp 1469-1472,2011.

[8] P. M Ayyasamy , R. Yasodha, S. Rajakumar, P.P Lakshamana, P.K S.M Rahmanands,Lee, "Impact of sugar factory effluent on the growth and biochemical characteristics of terrestial and aquatic plants" , Bulletin of Environmental Contamination and Toxicology , vol 81, pp 449-454, 2008,https:// doi .org /10.1007/s00128-008-9523-5.

[9] Yadav Sk, "Human health implications due to water toxicity by pulp and Paper Mill. J. Hum" Ecol.,2006;20(2):91-96.

[10] Karels Ae, Niemi A, "Fish community responses to pulp and paper mill effluents at the Southern Lake Saimaa, Finland", Environ Pollut., 2002;116:309-17.

[11] Mohn WW, Stewart GR , "Bacterial metabolisms of chlorinated dehydroabietic acids occurring in pulp and paper mill effluents" ., Appi Environ Microbiol., 1997; 63:3014-20.

[12] Yu Z, Stewart Gr . Mohn WW, "Apparent Contradiction:P sychrotolerant bacteria from hydrocarbon-contaminated Arctic Tundra soil that degrade diterpenoids synthesized by trees". Appi , Environ. Microbiol., 2000;66: 5148-54.

[13] Y. T. Sumathi , L..K. Wang , Y. T . Hungandh. H Yapijakis, "Treatment of pulp ssand paper mill wastes. in : wastes treatment in the process industries", Eds : Lo , Taylor & Francis 084937233 USA, pp 453-497,2006.

[14] S.N . Liss And P. A.Bicho, "Microbiology and biodegradation of resinacids in pulp mill effluents:A Mini Review, Cannadian", Journal of Microbiology , vol 75, Pp 599-611,1997 PMID :9246738.

[15] Pokhrel and T. Viraraghvan, "Treatment of pulp and paper mill wastewater – A Review," Science of Total Environment, vol 333, Pp 37-58,2004, Https://Doi.Org/10.1016/ J.Scitonev . 2004.05.017.

[16] "Dioxins and their effects on human health", World health organization , retrieved on 07/08/2018, fromhttp://www.who.in t/en/news-room/fact-sheets/detail/dioxins-and-their- effects –on-human health.

[17] Bhatngar, "Assessment of physico-chemical characteristics of paper industry effluents", Rasayan Journal of Chemistry, vol 8, number 1, Pp 143-145,2015, available at:http://rasayanjournal.co.in /vol-8,%20no.1, %20143-145,%20jan.-march ,%202015-rjc-1216.pdf.

[18] P. Tripathi, V. Kumar, G. Joshi, S.P. Singh, S.Panwar And S.Nithani, "A comparative study of physico-chemical properties of pulp and paper mill effluent", Journal of Engineering And Research Applications, vol 3, number 6, pp 811-818, 2013, available at:http://www.ijera.com/papers /vol3-issue6/eh3611818.pdf.

[19] M. K. Ahirwar, G.S.Gupta, N. Nirar And P. Ahirwar, "Monitoring of physico-chemical parameters of effluent release from orient paper mill, Amalai and Son River on Shahdol District, M.P" , Internationaljournal Of Innovative Research & Development, vo l4, number11,Pp 28-38,2015.

[20] Indian Fertilizer Sector At A Glance, Retrieved On 06-/07/2018,Fromhttps://Krishijagran.Com/Farm-Data/Indian-Fertilizer-Sector-At-Glance.

[21] G. Gangbazo, A.R.Present, G.M.Barentt,J.P.Chaurest And C.Cluis, "Water contamination by ammonium nitrogen following the spreading of hog manure and mineral fertilizers". Journal Of Environmental Quality , vol 24, pp420-425,1995.

[22] V. Palanievlu, K.E. Vijayavel And M.P. Balasubramaniam, "Impact of fertilizer (urea)on oxygen consumption and feeding the fresh water fish Oreochromis Mossambicus", Environmental Toxicology and Pharmacology, vol 19-pp 351-355, 2005, https://doi.org/10.1016 /J.etap.2004.09.001.

[23] C.D.A.Mclay, R.Dragten, G.Sparling and N.Selvarajah, "Predicting groundwater nitrate concentrations in a region of mixed agricultural land use". Environmental Pollutants, vol 115, pp 191-204,2001,http://dx.doi.org/10.1016/S0269-749(01)00111-7.

[24] D. Majumdar and N. Gupta, "Nitrate pollution of groundwater and associated human health disorders", Indian Journal of Environmental Health , vol 42, number 1, pp 28-39,2000. available at:http://www.academia.edu/1029029/nitrate_pollution_of _groundwater _and_associated_human_health_disorders.

[25] P. Sundaramoorthy, S.Saravanan, A.Subraman and A.S.Laashmanachary, "Toxicity effect of fertilizer factory effluents on seed germination and seeding growth of some agricultural crops", Pollutionresources, vol 19, number 4, pp 529-533,2000

[26] B. J .Wicks, R. Joensen, Q. Tang and D. J. Randall, "Swimming and ammonia toxicity in salmonids: the effect of sub lethal ammonia exposure on the swimming performance of Coho Salmon and the acute toxicity of ammonia in swimming and resting rainbow trout", Aquatic Toxicology, vol 59,pp55-69, 2002, PMID:12088633.

[27] E. Capkin, S.Kayis, H.Boran And . Altinok, "Acute Toxicity Of Some Agriculture Fertilizers To Rainbow Trout", Turkish Journal of Fisheries and Aquatic Sciences, vol 10, pp 19-25, 2010, available at :http://www.trijfas.org/uploads/pdf_372.pdf.

[28] Epa, "Nutrient Criteria Technical Guidance Manual-Rivers and Streams", EPA/65/R-95/008,Washington DC.2000.

[29] P. P . Singh M. Mall And J. Singh, "Impact of fertilizer effluent on seed germination, seedling growth and chlorophyll content on gram (ciceraeritenum)", Jounal of Environmental Biology, vol 27, number 1, pp 153-156, 2006, available at: https://pdfs. semanticscholar.org /c3ab/7161cd02851b0a572793aeeab6137ebf901.pdf.

[30] Odokuma, L. And Oliwe, O.S.I., "Toxicity of substituted benzene derivatives to four chemolithotrophic bacteria isolated from the New Calabar River", Global J Environ, Sci ,2(2): 7-77,2003.

[31] K. Verma, R. R. Dash And P. Bhunia, "A Review on chemical coagulation/flocculation technologies for removal of colour from textil wastewaters", Journal of Environmental Management, vol 93, number 1, pp 15-168,2012, https://doi.org/101016/j.jenvam.2011.09.012.

[32] N. Tufekei, N. and Sivriandl. Toroz, "Pollutants of textile industry wastewater and assessment of its discharge limits by water quality standards", Turkish Journal of Fish Aquatic Sciences, number7,pp 97-103,2007,.http://www.trjfas.org/uploads/pdf_319.pdf.

[33] P .Manikandan, P.N.Palanismay, R. Baskar, P. Sivakumarandp Satakshisharmila, "Physicochemical anlysis of textile industrial effluents from Tripur City, TN, India" , International Journal of Advvancedreserch in Sciencedand Engineerng, vol4, number 2, pp 93-104,2015.

[34] A.M.Talarposhti, T. Donelly And G.K.Anderson, "Colour removal from a stimulated dye wastewater using a two –phase anaerobic packed bed reactor", Water Resources, volume 35, pp 425-432,2001, PMID:11228995.

[35] Khandegar V, and Saroha AK, Electro coagulation for the treatment of textile industry effluent–a review. J Environ Manag 128:949–963, 2013, https:// doi. org/ 10. 1016/j. jenvm an. 2013. 06. 043.

[36] P.Kumar , B. Prasad, I.M..Mishraands. Chand, "Catalytic thermal treatment of desizing wastewaters", Journal of Hazardousmaterials, vol149, number 1, Pp 26-34, 2007, Pmid:17459578. doi:10.1016/J.jhazmat.2007.03.051.

[37] H. M.Pinheiroa, E. Toraudbando . Thomasb, "Aromatic amines from azo dye reduction:status review with emphasis on direct uv spectrophotometric detection in textile industry wastewaers", Dyes and Pigments, vol 61,Pp121-139, 2004,.doi:10.1016/J.Dyepig. 2003.10.009.

[38] S.Manjula, "Water pollution by industries:causes and consequences", The World Journal on Juristic Polity, vol 2, number 3, Pp 1-6,2016, available at: http://jurip.org/water-Pollution-Industries-Causes-Conseq uences/

[39] Azizi E, Fazlzadeh M, Ghayebzadeh M, Hemati L, Beikmohammadi M, Ghaffari HR, Zakeri HR, Sharafi K, "Application of advanced oxidation process (H2O2/UV) for removal of organic materials from pharmaceutical industry effluent". Environ Protect Eng, 2017, https:// doi. org/ 10. 5277/ epe17 0115

[40] Ruiz J, Alvarez P, Arbib Z, Garrido C, Barragan J, Perales JA, "Effect of nitrogen and phosphorus concentration on their removal kinetic in treated urban wastewater by chlorella vulgaris", Int J.Phytorem ,13(9):884–896, 2013,https:// doi. org/ 10. 1080/ 15226 514.2011. 573823

[41] Mohammadi L, Rahdar A, Bazrafshan E, Dahmardeh H, Susan M,Hasan AB, Kyzas GZ , "Petroleum hydrocarbon removal from wastewaters: a review", Processes 8(4):447,2020, https:// doi. org/10. 3390/ pr804 0447.

[42] Akpor OB, Ohiobor GO, Olaolu DT, "Heavy metal pollutants in wastewater effluents: sources, effects and remediation", Adv Biosci Bioeng 2(4):37–43, 2014, https://d oi.o rg/1 0.1 1648/j.a bb.2 0140 204. 11

[43] Kazi, T. G., Arain, M. B., Baig, J. A., Jamali, M. K., Afridi, H. I., Jalbani, N., " The correlation of arsenic levels in drinking water with the biological samples of skin disorders", Sci. Total Environ. 407 (3), 1019–1026, 2009, doi:10.1016/ j.scitotenv.2008.10.013

[44] Hanif, M., Miah, R., Islam, M., and Marzia, S., "Impact of Kapotaksha River Water Pollution on Human Health and Environment". Prog. Agric. 31 (1), 1–9, 2020,.doi:10.3329/pa.v31i1.48300

[45] Arif, A., Malik, M. F., Liaqat, S., Aslam, A., Mumtaz, K., and Afzal, A., "Water Pollution and Industries", Pure Appl. Biol. (PAB) 9 (4), 2214–2224, 2020, doi:10. 19045/bspab.2020.90237

[46] Vladeva, S., Gatseva, P., and Gopina, G., "Comparative Analysis of results from studies of goiter in children from Bulgarian villages with nitrate pollution of drinking water in 1995 and 1998. Cent." Eur. J. Public Health 8 (3), 179, 2000.

[47] Tseng, C.-H., Lei, C., and Chen, Y.-C., "Evaluating the health costs of oral Hexavalent chromium exposure from water pollution: A Case Study in Taiwan". J. Clean. Prod. 172, 819–826, 2018, doi:10.1016/j.jclepro.2017.10.177

[48] Zaveri, E. D., Russ, J. D., Desbureaux, S. G., Damania, R., Rodella, A. S., and Ribeiro Paiva De Souza, G., "The Nitrogen Legacy: The Long-Term Effects of Water Pollution on Human Capital", World Bank Policy Research Working Paper,2020.

[49] Zhuang LL, Yang T, Zhang J, Li X, "The configuration, purification effect and mechanism of intensified constructed wetland for wastewater treatment from the aspect of nitrogen removal: a review", Biores Technol, 2019, 293:122086. https:// doi. org/ 10. 1016/j. biotech. 2019. 122086

[50] Ebenstein, A., "The Consequences of industrialization: evidence from water pollution and digestive cancers in China". Rev. Econ. Statistics 94 (1), 186–201, 2012, doi:10.1162/rest_a_00150.

[51] Jorgenson, A. K., "Foreign Direct Investment and the Environment, the Mitigating Influence of Institutional and Civil Society Factors, and Relationships between Industrial Pollution and Human Health", Organ. Environ. 22 (2), 135–157, 2009, doi: 10.1177/1086026609338163.

[52] Golder B, Banerjee N, "Impact Of Informal Regulation Of Pollution On Water Quality In Rivers" In India Journal of Environmental Management 73,PP117-130, 2004.

[53] Sharma S.K , "An Assessment Of Plankton Diversity And Climate Change Relationship In Physico-Chemical Environment Of Son River In Bhojpur Area", 2014.

[54] Malik D ,Singh S , Thakur J , Singhn R K, Kaur A , Nijhawan S , "Heavy Metal Pollution Of The Yamuna River : An Introduction" Int J . Curr . Microbiol. App Sci 3(10),pp 856-863,2014.

[55] Srivatava V, Prasad C, Gaur A, Goel Dk, Verma A , "Physico-chemical and biological parameters investigation of River Ganga: from source to plain of Allahabad in India", European Journal of Experimental Biology ,pp 1-5,2016.

[56] Ahirwar M.K , Gupta G.S, Kirar. N, Ahirwar .P , "Study of heavy metal pollution from effluent of orient paper mill, Amalai", Intrnational Journal of Innovative Research and Development, pp 28-38,2015.

[57] Sahu, P., Karad, S., Chavan, S. and Khandewal, S., "Physiochemical analysis of Mula Mutha River Pune. Civil Engineering and Urban Planning : an International Journal, 2(2). 2015

[58] Akbal , F., Gurel, L., Bahadir, T. Guler, I., Baken, G. and Bayukgungor, H. , "Multivariate statistical techniques for the assessment of surface water quality at the Mid Black Sea Coast of Turkey". Water Air Soil Pollut,216, 21-37,2016.

[59] Kumar ,P., R. K. Kaushol and A.K Nigam, "Assessment and Management of Ganga River water quality using multivariate statistical techniques In India" . Asian Journal of Water , Environment and Pollution 12 (4):61-69,2015.

[60] Gyawali , S.K . Tecato and C. Yuangyai.2012, "Effects of industrial waste disposal on the surface water quality of U- Tapao River , Thailand", IPCBEE,32,pp .109-113, 2012.

[61] Thareja , S.S . Chaudhary and P. Trivedi, "Assessment of water quality of Ganga River in Kanpur by using principal components analysis". Advanced in Applied Science Research, 2(5):84-91,2011.

[62] Borthakur T.A, Kumar D, Singhal A, "Assessment of water quality of River Brahmputra in Guwahati of Assam", Conference Paper,2016.

[63] Kotoky P , Sarma B , "Assessment of water quality index of the Brahmaputra River of Guwahati City of Kamrup District of Assam . India", International Journal of Engineering Research and Technology(IJERT), pp 536-540,2017.

[64] Nath T. K, Tripathy B , Das A , "A study of water quality of River Brahmani, Odhisha (India) to assess its potability". International Journal of Engineering Research and Technology (IJERT),pp301-11, 2018.

[65] Das M.K , Samanta. S, Sajina , A . M., Sudheesan D , Naskarm, Bandopadhyay M.K , Pul S.K, Bhowmick S, Srivastava, P.K , "Fish Diversity" , Community,2016.

[66] Malikarjun Y , "Pollution Levels In Ganga Alarming" . The Hindu Mathivanan V , Vijayan. P , Sabhanayakams, Jeyachitra. O, "An assessment of plankton population of cauvery river with reference to pollution". Journal of Environmental Biology, pp 524-526,2003,2007.

[67] Agarwal , P.K., "A Review of Ganga River Pollution – Reasons and Remedies". Jounal of Indian Water Resources Society, 35(3),pp.46-52,2015.

[68] " Production of Sugar In Uttar Pradesh", Retrieved on 12/05/2018, https://www.google .com.in

[69] D.G. J. Larsson, P.C.De, N.Paxeus, Journal hazard matter, 148,75, 2007.

[70] J. Kreisberg, The Journal of Science and Healing, 1(2),133,2005.

[71] M Crane, C. Watts, T. Boucard, Science of the Total Environment,367,23 ,2006.

[72] B. Quinn, F. Gagne, C. Blaise, Science of the Total Environment,389,306,2008.

[73] K. M Gaworecki, S.J.Klanie, Aquatic Toxicology ,88,207,2008.

[74] J. K Stanley, A.J. Ramirez, C.K . Chambliss,B. W. Brooks, Chemosphere,69,9,2007.

[75] Adesalu , T.A, and Nwankwo, D.I, "Effect of water quality indices on phytoplankton of a sluggish tidal creek in Lagos,Nigeria", Pakistan Journal of Biological Sciences, 11,8336-844,2008.

[76] Mizes S.V and Demcheck D.K, "Water quality and phytoplankton communities in lack pontchatrain during and after the bonnet carr'e spillway opening, april to octber 2008, in Louisiana, USA", Geo-Marine Letters,29 (6),431-440,2009.

[77] Whitton B. A. and Patts M.,The Ecology of Cynobacteria Kluwer Academic Publishers, 2000, Netherlands.

[78] Kumar Amit and Radha Sahu, "Diversity of Alage (Chlorophycere) In Paddy Fields of Ialgutwa Area, Ranchi, Jharkhand". Japs vol .2(11):092-095,2012.

[79] Farihal Jabeen and Anjam H Barbhuiya, "Diversity of plankton population of Manas River, Assam"., India ISSN -0976-4550, 2018, dol:10.21276/Ijabpt,http://dx.doiorg/10.21276/.Ijabpt.

[80] Qadir, M., Drechsel, P., Jiménez Cisneros, B., Kim, Y., Pramanik, A., Mehta, P., & Olaniyan, O. (2020, February). "Global and regional potential of wastewater as a water, nutrient and energy source". In Natural resources forum (Vol. 44, No. 1, pp. 40-51). 2020. Oxford, UK: Blackwell Publishing Ltd.

[81] CPCB. Amended guidelines on the provision of buffer zones around waste processing and disposal facilities, Central Pollution Control Board, Ministry of Environment Forest and Climate Change (MoEFCC), New Delhi.2018.

[82] CPCB. Report of The Performance Audit of State Pollution Control Boards / Pollution Control Committees. Central Pollution Control Board, Ministry of Environment Forest and Climate Change (MoEFCC), New Delhi. (2020).

[83] CPCB. Status of STPSs. Central Pollution Control Board, Ministry of Environment Forest and Climate Change, Government of India. (Mar, 2021c). https://cpcb.nic.in/status-of-stps/

[84] Saravankumar kandasamy, silva de shanli, santosh siva sugavanewasrn, sathiyaseelan anbazhgan, ganeshlingam archchnana, jamla monca, sankaranarayanan alwarappan, vishnu priya veerarghavan, mubarakali davoodbaha, thripuranathar gobika, wang hyeon myeong. " impact of industrial effluents on the environment and human health and their remediation using MOFs-based hybrid membrane filtratin techniques". Chemosphere, volume 307, part 1, 2022.