International Archive of Applied Sciences and Technology
Int. Arch. App. Sci. Technol; Vol 9 [4] December 2018 : 111-121
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[ISO9001: 2008 Certified Organization]
www.soeagra.com/iaast.html

IAAST
ONLINE ISSN 2277- 1565
PRINT ISSN 0976 - 4828

CODEN: IAASCA **REVIEW ARTICLE**

DOI: .10.15515/iaast.0976-4828.9.4.111121

Water Pollution due to Discharge of Industrial Effluents with special reference to Uttar Pradesh, India – A review

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ABSTRACT
Rapid industrialization is a yardstick of development of a country; however, an increase in population growth affects it adversely. India, a developing country has a challenge of maintaining a balance between these and the environment. In India, there has been a fast growth in industrialization after independence. Uttar Pradesh is one of the highly populated states of the country. It has a large number of medium and large scaled industries by which effluents of complex and diversified nature are discharged causing in turn aquatic pollution. The present paper discusses the potential consequences of the impact of the industrial effluents on the biological system through the aquatic bodies in India, especially the U.P

Key words: *Heavy metals; Human health; Industrial effluents; Physico-chemical parameters; Uttar Pradesh; Water Pollution.*

Received 22/07/2018 Revised 20/08/2018 Accepted 09/09/2018

Citation of this article
Upma Singh, Shikha Singh, Rishikesh K. Tiwari and Ravi S. Pandey. Water Pollution due to Discharge of Industrial Effluents with special reference to Uttar Pradesh, India – A review. Int. Arch. App. Sci. Technol; Vol 9 [4] December 2018. 111-121.

INTRODUCTION

In India, though industrial revolution has facilitated the humans to advance further for the last two centuries, aquatic contamination by industrial discharges has been one of the critical issues of environmental concern. The advancement in science and technology resulted in the growth and spread of heavy industries which in turn caused industrial pollution. According to (1, 2) co-linearity in industrialization and population growth or the population catastrophe is the prime cause of expansion of industrialization and vice-versa (Figure 1). During series of processes, the water comes into contact with harmful chemicals, heavy metals, inorganic wastes and even organic sludge (3). These are either dumped into rivers or other water bodies which results in accumulation of high amount of industrial waste in them. This affects the status of our eco-system as well as the health of man, plants and animals.

Several incidences occurred throughout the world due to improper management or sheer accident leading to great damage to the ecosystem (Fig. 2). Oppau explosion (Germany), Chernobyl disaster (Ukraine), Halifax explosion (Canada), Benxihu colliery explosion (China) and the most disastrous one is Bhopal Gas Tragedy (India), are worst industrial/chemical hazards which caused violent death including side effects persisting till date (4, 5). Disposal of treated and untreated waste effluents from industries contain toxic metals and their chelates which contaminate nearby aquatic resources (6, 7).

Several factors contribute to the success in industries development, essential most being Labour force and natural resources. Uttar Pradesh has ample reserves of coal, dolomite and gems, diaspore, sulphur, magnesite pyrophallite, silica, sand and limestone due to which

many industries have flourished. Agra and Kanpur are the two major production centres of leather and leather products. So, around 200 large as well as small scale industries are situated in Kanpur along Ganga river bank and is sole reservoir for collecting sludge generated by industries. Mathura Refinery is the sixth largest oil refinery in India. Mathura, Ghaziabad, Gautam Buddh Nagar, Kanpur, Lucknow, Sonebhadra, Mirzapur, Balrampur and Varanasi are other most industrious areas in the state.

POLLUTION OF RIVERS IN UTTAR PRADESH DUE TO INDUSTRIALISATION:

Rivers are the chief contributor of human civilization. Ecologically, it helps in recharging ground water, controlling floods, supporting wild life and adaptation for climatic changes. Numerous tanneries, chemical plants, textile mills, distilleries, slaughterhouses, and hospitals prosper and flourish in a large number of industrial cities situated along the bank of the rivers where they cause pollution due to the discharge of untreated waste into it (8, 9). Ganges, the lifeline of the millions of Indians who live along its course caters their daily needs (10) however, presently this is highly polluted due to industrialization resulting in many hormonal and other physiological diseases (11- 13). Approximately 210,000 tons of fly ash (containing toxic heavy metals such as lead and copper) from coal-based power plant was dumped in Kanpur in Pandu River, a tributary of Ganges (14). Industrial effluents accounts for about 12% of the total volume of effluents being discharged in the Ganges. Though a relatively low proportion they are a cause for major concern due to their toxic and non-biodegradable nature (15). Table-1 shows the recommended guidelines for permissible limits of physico-chemical parameters and heavy metals in water recommended by BIS 2009 (16) for sustenance of better and healthy life for flora and fauna as more than ninety fiveper cent of industries are established along the rivers or aquatic ecosystem (Fig. 3). Since the industries discharge their effluents throughout the year and deteriorate the water quality of the rivers, only some specific industries and their effluents characteristic are discussed below on account of their distribution in Uttar Pradesh (Table. 2).

Table 1: Upper and lower permissible limit of some physico-chemical parameters and heavy metals in water BIS 2009 (16).

S No.	Parameters	Unit	Minimum permissible limit	Maximum permissible limit
1.	pH		6.5	8.5
2.	Conductivity	$\mu S\ cm^{-1}$	200	1000
3.	Turbidity	NTU	1	5
4.	Colour	TCU	5	15
5.	Total Dissolve Solid	$mg\ L^{-1}$	200	600
6.	Dissolved Oxygen	$mg\ L^{-1}$	3.5	5.0
7.	Hardness	$mg\ L^{-1}$	220	600
8.	Nitrate	$mg\ L^{-1}$	-	45
9.	Sulphate	$mg\ L^{-1}$	200	400
10.	Phosphate	$mg\ L^{-1}$	-	5
11.	Chloride	$mg\ L^{-1}$	250	1000
12.	Alkalinity	$mg\ L^{-1}$	200	600
13.	Total Ammonia	$mg\ L^{-1}$	-	0.5
14.	Mercury	$mg\ L^{-1}$	-	0.001
15.	Arsenic	$mg\ L^{-1}$	-	0.01
16.	Cadmium	$mg\ L^{-1}$	-	0.003
17.	Lead	$mg\ L^{-1}$	-	0.001
18.	Iron	$mg\ L^{-1}$	-	0.01
19.	Copper	$mg\ L^{-1}$	-	1.0
20.	Chromium	$mg\ L^{-1}$	-	0.05

Table 2: List of industries distributed in seventy-four districts of Uttar Pradesh and their major discharges responsible for deterioration of water quality.

S No.	Industries	Major components of effluent/industrial waste	Distribution (Districts)	Ref.
1.	Sugar	Sugar, Molasses, Alcohol and Heavy Metals	Devaria, Gorakhpur, Barabanki, Basti, Sitapur, Muzaffarnagar, Ghaziabad, Kanpur, Faizabad, Jaunpur.	(27, 28)
2.	Paper and pulp	Chlorinated complex products, dibenzo-p-dioxin and benzofuran	Meerut, Saharanpur, Muzaffarnagar	(34, 35)
3.	Aluminium	Heavy metals (Cd, Mn, Pb and Zn)	Renukoot	(75)
4.	Chemical fertilizer	Ammonia, urea, heavy metals	Gorakhpur, Varanasi, Allahabad, Pratapgarh	(52)
5.	Engineering (Heavy machines and spares)	NA	Naini	
6.	Cycle	NA	Kanpur, Agra, Varanasi,	
7.	Glass	Chloride, Fluoride, Heavy metals (Iron, Chromium, Cadmium and Nickel)	Firozabad, Naini, Shikohabad	(57, 58)
8.	Leather	Acids, alkalis, chromium salts, tannins, solvents, sulfides, dyes, heavy metals etc.	Kanpur, Agra	(76)
9.	Plastic	Polyolefins and polyethylene terephthalate (PET)	Kanpur, Varanasi	(77)
10.	Petrochemical	Polycyclic and aromatic hydrocarbons, phenols, metal derivatives, surface-active substances, sulphides, naphthylenic acids and other chemicals	Lucknow	(78_
11.	Textile	Dyes and pigments, presence of detergents and surfactants	Kanpur, Allahabad, Noida, Ghaziabad, Lucknow, Agra, Saharanpur, Gorakhpur Modinagar, Varanasi, Rampur.	(20)
12.	Thermal-power plant	Coal dust, CO_2, fly ash, chlorinated water, heavy metal residues (Hg, Bi, As, Cr, Cu, Pb)	Unchahar, Rihandnagar, Shahjahanpur, Jhansi, Aligarh, Renusagar, Obra, Anpara	(65, 66)

IMPACT OF INDUSTRIAL EFFLUENTS ON HUMAN HEALTH:

Industrial discharges are the major sources of aquatic pollution. Depending on type of industry, various types of pollutants are released into the environment directly (industrial outlets) or indirectly (domestic sewages) due to various anthropogenic activities which in turn may pose serious threat to human health. Wastewater released from various industries has high concentration of organic pollutants, toxic components such as heavy metals, pesticides, polychlorinated biphenyls (PCBs), dioxins, poly-aromatic hydrocarbons (PAHs), petrochemicals, phenolic components etc. These are harmful for surrounding water bodies, human health and aquatic life if discharged directly into the aquatic medium (17). When industrial effluent containing heavy metals (Cr, Pb, Hg, Ni, Cu, Zn, As, Cd etc.) reaches into the aquatic ecosystem, its biomagnifications takes place through food chain. Progress in toxicology has advanced our knowledge regarding the excessive accumulation of heavy metals and their adverse impacts on human health including developmental retardation, cancer, kidney damage, endocrine disruption, immunological disorders (autoimmunity) and even death (18).

TEXTILE INDUSTRIAL EFFLUENT AS SOURCE OF WATER POLLUTION:

In India, textile industry is considered as an important source 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 (19). It was observed that the textile effluents are highly coloured due to presence of dyes/pigments, detergents and surfactants in effluent deteriorates the quality of receiving medium and impose threat to inhabitants (20).
Manikandan et al (21) has reported that textile industry effluent discharge was turbid and coloured, loaded with organic and inorganic constituents, hardness (due to higher concentration of sulphate, chloride, calcium and magnesium), alkalinity, pH, conductivity and low BOD/COD ratio which indicate the presence of large proportion of non-biodegradable organic matter being unsuitable for direct discharge in aqueous bodies without treatment. Similar reports also suggested that the values of most hydrobiological parameters were higher than the permissible ranges in drinking water, thereby rendering the aquatic bodies polluted and unfit for agriculture, domestic and habitat for aquatic species (22, 23). Industrial activities like electro plating, metal cleaning and dyeing processing, cement, and leather tanning are the major sources for releasing chromium (particularly chromium sulphate) and aromatic amines into the environment, having carcinogenic effect on human health (24).

SUGAR INDUSTRY EFFLUENTS AS SOURCES OF WATER POLLUTION:
Uttar Pradesh is the traditional producer of sugar and has the second rank with approximately 105 sugar industries 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 produced annually (25). Beside the main product, Sugar, the mill also generates various byproducts which pose significant impact on the environment. Sugar mill effluent generated in various steps release molasses, alcohol, many by-products and liquid wastes as major pollutants for the local rivers and lakes (26 - 28).
In India, use of phosphoric acid and sulphur dioxide during clarification of sugar cane juice is the main cause for the occurrence of algal bloom which subsequently colours this dark and increases BOD, COD, suspended solids (SS), unpleasant odour and heavy metals (Fe, Cu, Zn, Mn, Pb) (29). High value of COD indicates the high organic load due to recalcitrance of chemicals that have escaped biodegradation (30). Further these heavy metals present in aquatic ecosystem may accumulate in fish and enter into human metabolism through their consumption and results in bioaccumulation (31).

PAPER AND PULP INDUSTRIAL EFFLUENT AS SOURCES OF WATER POLLUTION:
Paper and kraft mill effluent is the highly polluted one as it utilizes a huge amount of lignocellulosic materials and water during manufacturing processes and thus chlorinated complexed byproducts like trichlorophenol, trichloroguicol, dichlorophenol, dichloroguicol, pentachlorophenol, dibenzo-p-dioxin and benzofuran become the main components of the effluent (32 - 34) which are responsible for higher biological and chemical oxygen demand (35); out of which dioxins 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 with hormones and also cause cancer (36).
A high value of physico-chemical parameters like colour, pH, suspended solid, BOD and COD in the treated effluent as per Indian Standards was observed by Bhatnagar (37). Similar findings by other workers corroborate the cause of pollution of aquatic bodies due to paper and kraft mill effluents (38 - 41).

CHEMICAL FERTILIZER INDUSTRIAL EFFLUENT AS SOURCES OF WATER POLLUTION:
India is the world's second largest consumer of fertilizers followed by China. The Indian fertilizer industry meets 80 percent of its Urea fertilizer needs (42). Effluent from fertilizer industry contains 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 (43, 44). Ground water contamination by nitrate is a growing problem throughout the world due to intensive use of fertilizers in agriculture (45), causes a number of health disorders, namely, methaemoglobinemia, gastric cancer, goitre, birth malformations, hypertension, etc (46).

According to Sundaramoorthy and his co-workers (47), fertilizer industry is one of the major water consuming industry and responsible for water and soil contamination adequately. Ammonia, the main component of fertilizer, exists in two interconvertible forms in water i.e. unionized ammonia (more toxic) and ammonium ions (less toxic) and their ratio can be controlled by pH and temperature (48, 49). Heavy metals and other dissolved contaminants have been identified by EPA 2000 (50) as primary toxicant i.e. these are persistent, bioaccumulative and toxic.

An analysis of the effluent of a fertilizer industry situated in Sultanpur, Uttar Pradesh showed similar results to that of the same from other places. it was reported that the light brown effluent had higher pH, EC, BOD, COD, TDS, nitrogen, phosphate, sulphate content, low level of dissolved oxygen and presence of heavy metals (51- 55).

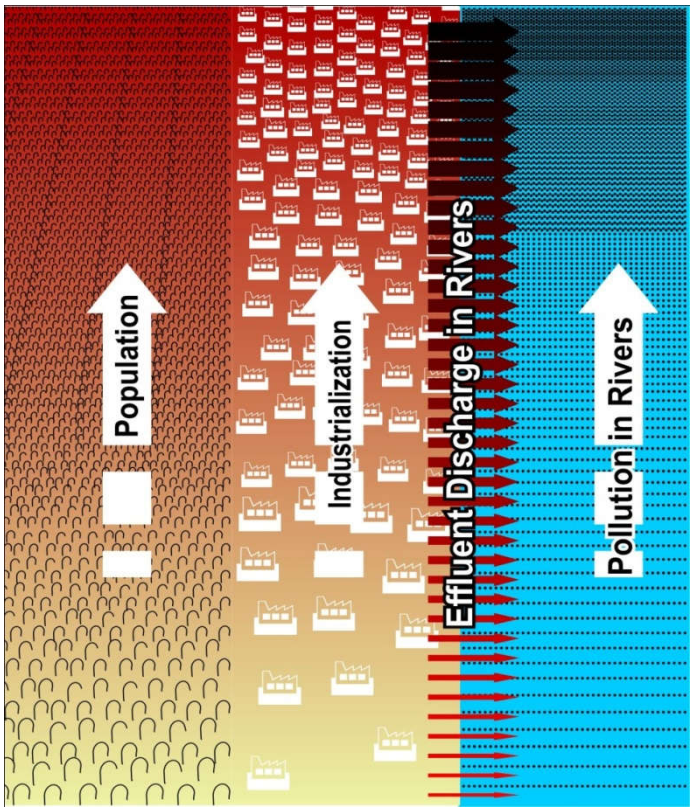

Figure 1: Level of contamination in Rivers increases due to growth of industries and population. Contamination in rivers w.r.t. population and industrialization

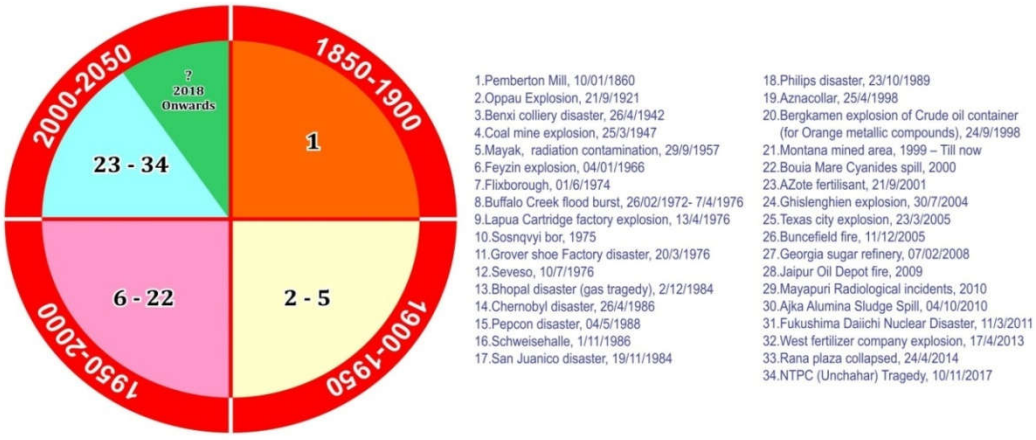

Figure 2: Pie chart representing reported cases of industrial hazards (1850-2017); source (73)

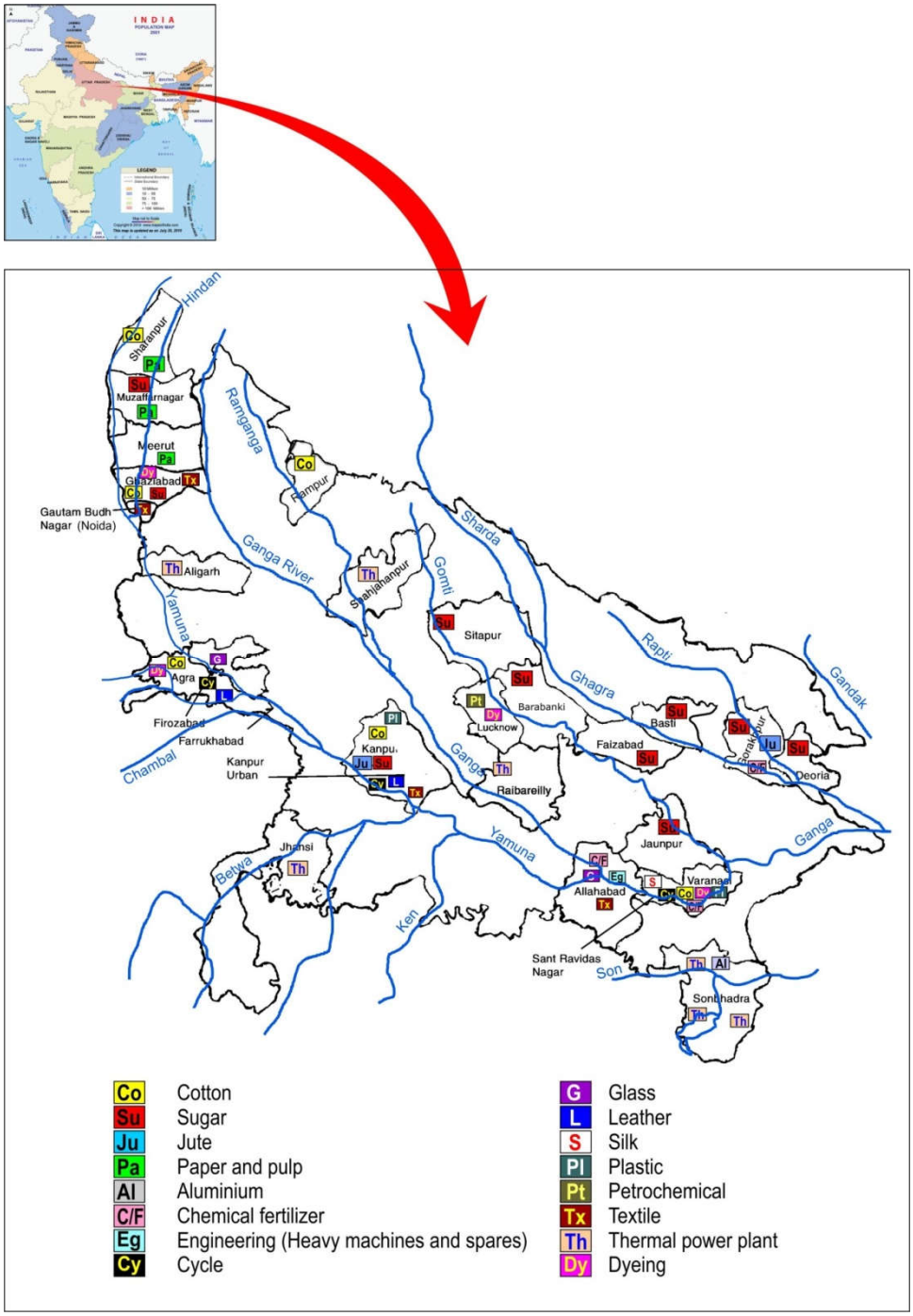

Figure 3: Distribution of industries along riverine system in Uttar Pradesh.

GLASS INDUSTRIAL EFFLUENT AS SOURCES OF WATER POLLUTION:

Glass industry is one of the miscellaneous industries which generate polluting effluents (56). Sand or Silica(Si) or SiO_2 are the major constituent of glasses constituting about 70% further followed by carbonates of Ca, K, Na and Ba (57) and heavy metals for used for colouration.

Presence of High concentration of Alkalinity, COD, BOD, Chloride, Fluoride, Heavy metals (Fe, Pb, Cr, Cd and Ni) was reported from analysis of glass industry effluent situated in Firozabad, Uttar Pradesh (58, 59). Presence of lead may cause gastrointestinal tract, respiratory tracts, kidneys, and central nervous system disorders (60).

THERMAL POWER PLANT EFFLUENT AS SOURCES OF WATER POLLUTION:

There are about more than 200 power plants in India out of which 116 are coal

based/thermal, 65 are gas based and 19 are diesel based. Thermal power plants solely produce 71% of electricity (61). Thermal pollution is hazardous as it results in increase in temperature due to discharge of warm water which causes subsequent changes such as depletion of dissolved oxygen and disruption in ecological balance of the medium in which these are released (62 - 64). Coal dust, CO_2, fly ash, chlorinated water and residues of heavy metals (Hg, Bi, As, Cr, Cu, Pb) are the main constituents of thermal power pollutants. (65, 66).

An adequate data is available in literature confirming the presence of fly ash heavy metals like Cr, Zn, Mn, Cu, Pb, Co and Ni in thermal power sludge, out of which Cr and Zn concentrations are the highest (67, 68). Javed (69) in his study on rivulet in Kashimpur, Aligarh which receives wastewater from thermal power plant (Harduaganj) reported the presence of heavy metals and their concentration in following order Cu> Zn> Mn> Ni> CO> Cr. Heavy metals not only get accumulated but also affect the metabolism of inhabiting species like fish, *Channa punctatus*. A common suggestion by a number of scientists working on this aspect is that the effluents should be treated, concentration of heavy metals and other contaminants minimised prior to its discharge (70 - 72).

CONCLUSION

To cater the needs of increasing human population there has been a parallel growth in industries however this has posed a serious problem too. The accidental discharges and/or inadequate management of untreated effluent is one of the global concerns as disastrous effect on aquatic organisms exposed to these discharges are imminent. In Uttar Pradesh, most of the industries are situated along the bank of rivers and one of the major causes of their pollution is the discharge of untreated waste into these. Keeping this into account, Government of India has made it mandatory to treat the effluents prior to discharge, non-compliance draws heavy penalty. All such industries are expected to install a waste water treatment plant/unit so that the pollution due to discharge of sludge/effluents be minimized if not completely stopped.

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