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SUSTAINABILITY CHALLENGES OF THE AAMI RIVER: A HOLISTIC REVIEW

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Abstract

The Aami, being the most significant river of Gorakhpur region flows for around 126kilometres before joining the Rapti River close to the village of Sohgaura in Tehsil Bansgaon, district Gorakhpur. In Eastern Uttar Pradesh, it is a tributary of the Rapti River and provides a lifeline to the residents of Siddharth Nagar, Sant Kabir Nagar, Basti, and Gorakhpur districts. Industrial effluents are received on its right rear bank at various locations into the Rapti river from Rudhauli to its confluence with the Sohgaura.Industrial effluents have had a negative impact on the river's water quality ever since the construction of the paper mill in Khalilabad, the distillery, and the sugar factory in the Gorakhpur industrial development region. A major environmental impact of GIDA (Gorakhpur Industrial Development Authority), Sahajanwa, is significant not only for its contribution to Indian economic growth but also for the pollution of River Aami which serves as the foundation for household and agricultural needs for those who live nearby.Numerous enterprises owned by GIDA are rated both nationally and state-wise, including the sole jute mill in Uttar Pradesh, power looms, plywood, and footwear manufacturers IGL (India Glycol Limited), Parle, and ARP (Azam Rubber Products). The river's section between Rudhauli, Basti, and Sohgaura, Gorakhpur, has been designated as contaminated. Assessing the effects of urban and industrial activities on the water quality of the Ami River in Eastern Uttar Pradesh was the primary objective of the current study. The work is important because it aims to educate field engineers and researchers working in the field about the latest advancements in water quality and its management. This will help them plan and design water quality monitoring programs more effectively and handle issues and problems related to water quality.

Keywords

River Aami, Historical relevance, Industries, Satellite images, NDVI, NDBI, NDWI, LST, Industrial effluents, Fish diversity, Plankton diversity, Water Treatment Plant.

I. GEOGRAPHY:

The Ami River is a 126-kilometer river that originates fromSikhaira Taal, Sant Kabir Nagar and empties into the Rapti River at Sohgaura, close to Kauriram, in the Gorakhpur district (Fig.1).

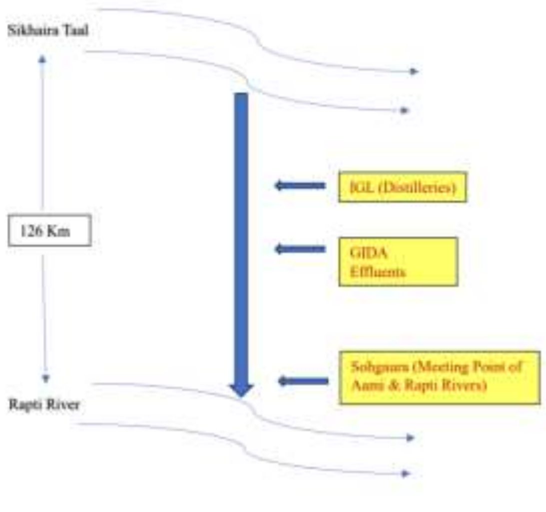
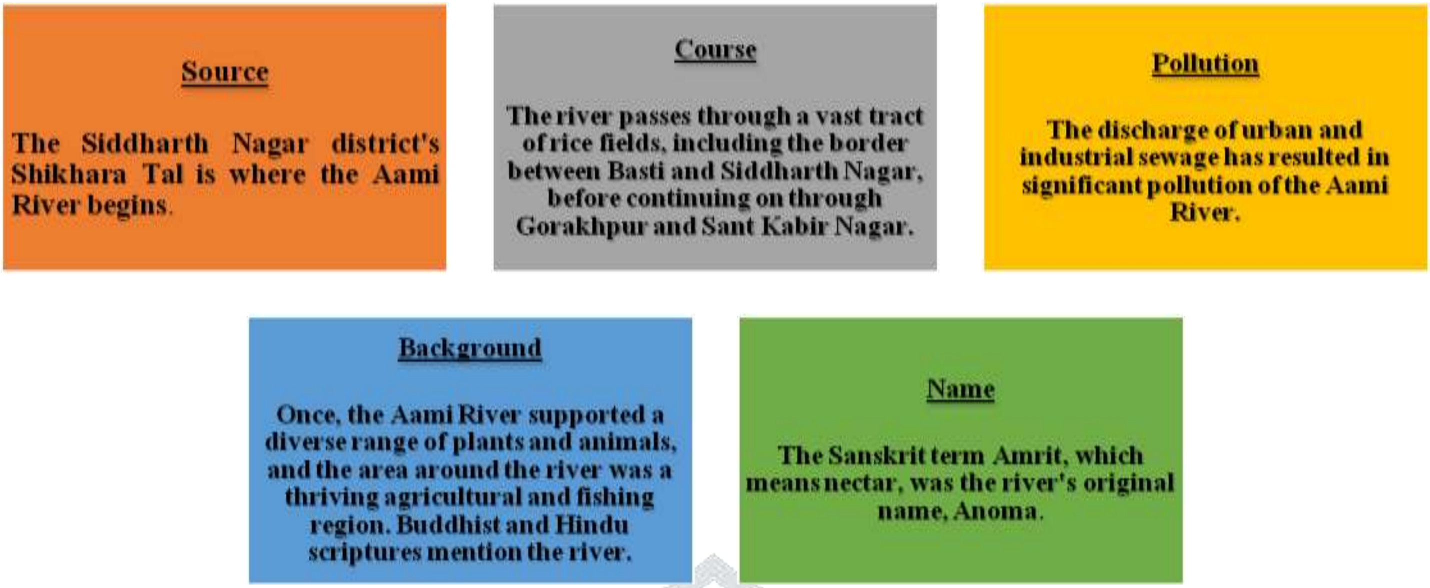


Fig 1: Route of Aami River from Sikhaira Taal (origin point) to Sohgaura



Secondary data was primarily gathered from articles in publications such as Dainik Jagran, Hindustan, Amar Ujala, and English. A qualitative examination of published writings in various newspapers was conducted to understand River Aami's history. Additionally, reports from the Central and State Pollution Control Boards were considered.

II. HISTORICAL RELEVANCE:

Like Ganga, Aami is a sacred river of North-Eastern U.P. which originates from Shikhara Taal and eventually meets River Rapti at Sohgaura.

It is comparable to the Ganga, since Siddhartha became awakened as Lord Buddha, chopped off his hair and lived a solitary life by the river's edge. At Maghar, on the Aami River's bank, where Sant Kabir' 'Samadhi' is located, he attained 'mahaparinirvan' and took his last breath.

Archaeologists uncovered a 5000-year-old civilisation in Sohgaura hamlet, located on the bank of Aami River. Guru Nanak and Guru Goraksh Nath paid a visit to Maghar and met Sant Kabir, a Gurudwara was built to commemorate the occasion.

Followers of Kabir took the water of Aami on a boat to their various dwellings to consume as holy water.

The river's water was so beneficial to health that the nearby villages became an ideal location for nurturing well-known wrestlers and swimmers. The abundance of fish in this river supported the fisherman's economy. The river's water was used for irrigation.

2.1 Aami Bachao Movement: A Historical Overview

2.1.1 Cause of Protest-

Pollution from industries in Gorakhpur Industrial Development Authority, paper mills, and Sant Kabir Nagar had reached hazardous levels in the river. Industrial trash was dumped straight into rivers, producing significant contamination. Urban waste and rubbish polluted rivers. This caused the river's water to become black. The government has permitted a few enterprises to pollute the sacred river, resulting in the death of nearly all fish and putting the lives of thousands of villagers on the banks at risk. Dogra emphasizes the importance of safeguarding the Aami River from contamination, as it is a lifeline for many villages. For thousands of years, Aami has provided residents on both banks of the river with abundant and healthy water. Previously, river water could be used for irrigation, but now it is polluted and detrimental to crop growth. Polluted water caused many dairy and farm animals to die or become unwell. The river's once abundant fish and aquatic species are no longer present. Approximately 2.5 lakh fisherman have been affected by this. The water from hand pumps is also contaminated, leading to the spread of water borne infections among people. Pollution of the river has caused people to avoid performing funeral practices on its banks.

2.1.2 Mode of Protest-

Under the direction of local politicians and social activists, those impacted by the river's pollution came up to establish an Aami Bachao Manch in 2009. An influential figure in the region, Vihwavijai Singh, serves as the forum's president. With the exception of one instance of violence against pollution board officers in 2011, the campaign has been nonviolent for years. People demanded that a common effluent treatment plant, or CETP, be built in the industrial region. The garbage generated by industrial facilities would be cleaned up by this treatment facility. The movement's leadership promoted the idea that the communities' economies and culture heritage along the riverbanks were in danger. They asserted that the erratic electrical supply and the industrialists' lack of interest are the reasons why pollution control units in enterprises do not operate effectively (Hindustan, 25 February, 2014). Local residents protested by performing a deep-daan in the river in October 2009. They promised to keep fighting to rid Aami of pollution. Additionally, protests in various forms persisted throughout 2010. The forum organized a bandh on February 15, 2010, with the help of local businesspeople. The majority of the marketplaces were shut down. The movement also included folk artists. They brought up the subject with the aid of the traditional tunes "Faruhayi dance" and "Birha."In order to bring attention to the problem, a rather unusual kind of protest was carried out by holding religious ceremonies like Hawan and Pujan. The local ladies, who assembled with sticks and belan to express their protest, took on another intriguing approach."Ghera Dalo-Dera Dalo" was a program organized by Aami Bachao Manch in the Gorakhpur district headquarters from November 4–6, 2011.

Officers from the regional pollution board had to deal with violence in Katka village in April 2011 as the peaceful protests descended into violence. Police filed a formal complaint against 100 anonymous individuals. Nonetheless, a number of leaders and political parties backed the campaign and put pressure on the government to drop the prosecutions. Positive outcomes began to emerge after Aami Bachao Manch's protracted battle, which included a protest movement and constant pressure on the government After considering the situation, the Central Pollution Control Board (CPCB) sent a team to the region to gather a river water sample and assess the quality of the groundwater nearby. The 2012 CPCB report, made it apparent that the Aami River was contaminated and that the relevant authorities needed to take the required actions to clean it up.

In order to address the issue of pollution in the Aami River, the GIDA board ultimately decided to install CEPT in 2014 during their annual meeting and allocated 60 crore rupees from its budget.

Fig 2: Maghar: Bank of River Aami

Fig 3: Image showing present condition of River Aami

III. PRESENT SCENARIO

3.1 SIGNIFICANT INDUSTRIES OF THE REGION:

(a) India Glycol Limited (IGL)- Among the leading manufacturers of glycols and other chemicals in India is India Glycol Limited (IGL). The following details pertain to the business's facility in GIDA Gorakhpur:
The address is AL-5, Sector 23, GIDA, India Glycols Limited. In 2001, IGL, which was initially established in New Delhi in 1983, created a GIDA Gorakhpur branch. The company produces a variety of materials, including natural gums, bio-polymers, acetates, edible alcohol, glycols, and glycol ethers.

Satellite Images: Fig 4 & 5 are the satellite visuals of the year 2005 & 2024 respectively. The visuals are clearly indicating the increment in the level of pollution. Darker visual indicates more pollution whereas lighter visual indicates less pollution.
The pollution level has drastically increased from the year 2005 to 2024.

Fig 4: Temporal Image of IGL in the year 2005.

Fig 5: Temporal Image of IGL in the year 2024.

(b) Gallant Ispat Limited- Gallant Ispat Limited is a steel production firm based in Gorakhpur, Uttar Pradesh, India. The business is located in the GIDA industrial area at AL-5, Sector 23, Sahjanwa. Among other steel products, they manufacture sponge iron, M.S. billets, and wheat flour. The company has a wealth of experience in both supplying and trading these commodities. Since its establishment in 2005, Gallant Ispat Limited has grown to become one of the leading manufacturers of steel products in India.

Satellite Images: Fig 6 & 7 are the satellite visuals of the year 2005 & 2024 respectively. The visuals are clearly indicating the increment in the level of pollution. Darker visual indicates more pollution whereas lighter visual indicates less pollution.
The pollution level has drastically increased from the year 2005 to 2024.

Fig 6: Temporal Image of Gallant Ispat Limited in the year 2005.

Fig 7: Temporal Image of Gallat Ispat Limited in the year 2024.

(c) GRL Edibles Pvt. Ltd- Located in Barpahi, Gorakhpur.The company focuses on the production and sale of various edible oils.

Satellite Images: Fig 8 is the satellite visual of the year 2024. The visual is clearly indicating the increment in the level of pollution. Darker visual indicates more pollution whereas lighter visual indicates less pollution.

Fig 8: Temporal Image of GRL Edibles Pvt. Ltd in the year 2024.

(e) Bajaj Hindusthan Sugar Ltd.- The top producer of sugar and ethanol in India is Bajaj Hindusthan Sugar Ltd. (BHSL). With its headquarters located in Mumbai, Maharashtra, India, Bajaj Sugar is a significant part of the Bajaj Group.
The corporation runs only 14 sugar mills in Uttar Pradesh (UP). Gola Gokaran Nath, Palia Kalan, Khambharkhera (Lakhimpur Kheri district), Barkhera (Pilibhit district), Kinauni (Meerut district), Gangnauli (Saharanpur district), Thanabhawan and Budhana (Muzaffarnagar district), Bilai (Bijnor district), Maqsoodapur (Shahjahanpur district), Pratappur (Deoria district), Rudhauli (Basti district), Kundarkhi (Gonda district), and Utraula (Balrampur district) are all strategically located.

(f) Rayana Paper Board Industries Ltd- The company has an established capacity of 16,500 tons per annum (TPA) for the production of industrial paper and writing and printing paper (WPP). Two of the company's manufacturing sites are in Gorakhpur, Uttar Pradesh. It exports to Nepal and Bhutan in addition to selling its paper goods throughout India under the "RAYANA" brand.

(Satellite Image Source: Google Earth)

IV. INDUSTRIAL EFFLUENTS

Man has utilized water more than any other natural resource for the maintenance of life, despite it being an indestructible resource. Uncontrolled sewage disposal, industrial pollution, and human activity are all contaminating this elixir of life. The concentration of different solutes at a specific location and time is present in water quality data. According to Boyd and Tucker (1998),Jayabhaye et al. (2006), and Shinde et al. (2011), water quality metrics serve as the foundation for determining whether water is suitable for its intended applications and for enhancing current circumstances. With the growth of industries and population, development has altered the environment in many unfavourable ways. Because of poor management and human ignorance, the aquatic ecosystem of water bodies has been disrupted. This has led to the emergence of new environmental issues and new concepts in the field of aquatic ecosystem monitoring and evaluation. As the number of industries and people has grown, development has resulted in numerous unfavourable changes to the environment. Mismanagement and human ignorance have disrupted the aquatic ecosystem of water bodies. As a result, new environmental issues have emerged, leading to fresh concepts in the field of aquatic ecosystem monitoring and assessment.

4.1 Physical attributes of industrial wastewater- The solid content, colour, odour, and temperature of effluent are its primary physical attributes. The total solids in wastewater are made up of both soluble substances dissolved in water and insoluble or suspended particles. According to Canter, L.W. (1988)., approximately 59% of the suspended solids in industrial wastewater are typically settleable, compared to 40–65% of the suspended solids in ordinary wastewater (Ali, I; Mohd. Asim, and Tabrez A. Khan,2012). Another way to classify solids is into those that volatilize at high temperatures (600°C) and those that don't. The overall quality of wastewater can be evaluated using colour, a qualitative feature. If the wastewater eventually turns shades of grey or black, it has likely experienced extensive bacterial breakdown in anaerobic circumstances, which is frequently brought on by the buildup of particular sulphides, particularly ferrous sulphide. Fresh wastewater normally doesn't smell bad, but when wastewater breaks down biologically in anaerobic environments, a number of odorous chemicals are generated, with H_2S—the smell of rotten eggs—being the main one. Additional substances that were produced in anaerobic environments or found in the effluents include indole, skatole, cadaverine, and mercaptan. Since warm industrial effluent has been added, wastewater often has a greater temperature than the water source.
Seasonal variations in wastewater temperature are possible, as is geographic location. Temperatures in colder climates range from roughly 7 to 18°C, whereas those in warmer climates range from 13 to 24°C.

4.2 Chemical attributes of industrial wastewater- Inorganic and organic compounds, heavy metals, and other species are present in industrial effluent. Alkalinity, pH, hardness, DO, COD, BOD, free ammonia, organic nitrogen, nitrites, nitrates, organic phosphorus, phosphorous inorganics, chloride, sulphate, trace elements, including some heavy metals, and other factors are crucial effluent characteristics.
Manufacturing plant wastewater is reliant on these kinds of industrial sources and contains a wide range of organic contaminants.

4.3 Causes of Industrial Wastewater Pollution: The following are the main causes of industrial pollution.
- The prevalence of antiquated, ineffective, and outmoded technology that produce more pollution than contemporary ones.
- The vast unplanned industrial conglomerate has gravely contaminated their surroundings and encroached upon them.
- There are numerous small-scale companies that circumvent land use and occasionally even environmental rules.
- Strict pollution control regulations are lacking, and they are not well enforced or supported by resources.
- Insufficient awareness and concern.

4.4 Effects of Industrial Discharge

Waste generated by various industrial processes can eventually change the water's temperature, pH, and colour. It can also make the water murkier and increase the concentrations of minerals, salt, and nutrients. The effects of wastewater pollution on the ecosystem can be extensive. When discharged outdoors or onto agricultural land, manufacturing wastewater can contaminate the soil with organic pollutants and heavy metals. The fertile land is turned into unproductive land by the drainage of industrial effluents. The issue of groundwater pollution occurs if the contaminants seep into the soil and reach the subterranean aquifers (Bharti, P. K.,2012).

Even in pristine aquatic ecosystems, contaminants exist in trace amounts. For fish and shellfish, certain metals—like copper, zinc, iron, and selenium—are vital nutrients. When their levels significantly rise, contamination takes place. Almost all issues pertaining to chemical contamination of the aquatic environment are caused by humans. Raw, untreated sewage from industry and urban populations, agricultural runoff, sewage treatment plant sludge, and industrial effluents all contribute to environmental chemical contamination.

However, the primary worry of harbour managers is that fish processing, ice production, and washing require clean water that is chemically comparable to drinking water. When found in water at levels over a specific threshold, several substances can pose a risk to public health.

Numerous contaminants have been released into the environment in recent decades as a result of rapid population growth and industrialization, especially in the form of industrial effluents.The complex mixture of organic and inorganic materials found in these effluents may negatively impact the physicochemical characteristics of the receiving water bodies, according to Venturino et al. (2016), Hegede et al. (2021), (Tigga& Pandey, 2023).Industrial water contamination poses a major hazard to aquatic environments and human health. Numerous enterprises discharge untreated or partially treated waste into water bodies, altering their biological and physicochemical properties (Diwakar & Dwivedi, 2022). These effluents contain contaminants that can harm agriculture yields, kill aquatic life, and degrade surface and groundwater quality (Ibrahim et al., 2021).In the industrial area of Gorakhpur, there is growing concern over water contamination, which affects both surface and groundwater. Yadav (2023), Agrahari & Kushwaha (2012) claim that the Ramgarh Tal and River Rapti have significantly degraded due to industrial discharge, domestic sewage, and agricultural runoff. Turbidity, nutrients, and microbiological contaminants are all present in high proportions in these bodies of water, often exceeding the permissible limits set by ICMR/BIS guidelines (Yadav, 2023). Rivers that receive untreated sewage flow have seen a drop in dissolved oxygen and pH as well as an increase in TDS, electrical conductivity, and other chemical parameters (Agrahari & Kushwaha, 2012). Groundwater quality in Gorakhpur's urban and semi-urban areas is also affected; certain samples show high levels of total dissolved solids, hardness, and pH issues (Apoorv & Govind, 2014). This pollution poses a major risk to aquatic ecosystems, human health, and sustainable water resource management.

Research indicates that appropriately treated industrial effluent can considerably reduce the contaminants in the water, hence making it safer to discharge into the environment (Ahmad, 2018). Numerous uses for treated industrial effluent exist, such as drinking water delivery systems, industrial operations, and irrigation. Clean industrial effluents can benefit firms monetarily in addition to their environmental benefits. Reducing wastewater treatment and disposal costs allows industries to invest more in production and other endeavours (Chen et al. 2019).

The condition of the river remains the same as before or can be said to have been detoriated even more. Continuous studies are being done for analysing the physico-chemical parameters of the river water along with the diversity status of the living flora and fauna.

Table 1: Types of Pollutants, Origin of Pollutants, their Damaging effect and Preventive Action needed.

	Pollutants	Origin	Damage	Preventive action needed
1.	Suspended Solids: silt and colloids	Domestic and industrial waste, Soil Erosion	Inhibit Photosynthesis silt up rivers and lakes	Treat waste change water flow
2.	Dissolved mineral salts; Phosphates Nitrate Calcium and Magnesium bicarbonate Calcium and Magnesium sulphates	Sewage washing powders Farmyard waste Fertilizers Soil Industrial waste mining.	Eutrophication- weed growth Foam Toxic to young babies' Temporary hardness Permanent hardness	Biodegradable washing powders Divert waste flow
3.	Organic residues	Sewage-farmyard waste industrial wastes, e.g. paper and pulp industry.	Increased BOD, damages fish, encourages anaerobic bacteria	Proper sewage treatment
4.	Toxic chemicals; DDT Metal ions Phenols Oil	Pesticides Industrial waste Disinfectants Spoilage from factories and ships.	Kill fish and birds kill organisms and after pH Kill organisms Clog respiratory system of animals, prevent O2 uptake at water surface	Test first Remove from effluent Remove with detergent
5.	Heat	Factory water coolers	Less dissolved O2 for organisms affected	Increase flow
6.	Pathogens; *Entamoeba histolytica Shigella Vibrio cholerae Salmonella sp. Leptospira Enterobius Schistosoma Ancylostoma*	Sewer rats	Amoebic dysentery Bacillary dysentery cholera Typhoid, paratyphoid and food poisoning leptospirosis nematode worm's bilharzia hookworm	Water purification Proper disposal of faeces Hygienic food preparation immunisation Destroy rat's hygienic food preparation Destroy snails Avoid contact with skin
7.	Vectors mosquitoes; *Anopheles, Aedes, Culex*	Adults lay eggs in stagnant water	transmit filarial worms transmit malaria Plasmodium transmit yellow fever virus transmit dengue virus	Insecticides, spray oil on water surface, take drugs, e.g. Paludrine
8.	Radiation; Radionuclides	Power station wastes X rays	mutation	Use screens nuclear testing ban
9.	Trace elements; Arsenic Chromium Cooper Iron Lead Manganese Mercury Selenium Zinc	Mining by product & chemical waste Metal plating & tannery Metal plating industrial waste Mining, industrial waste Natural source Industrial waste	Toxic (carcinogenic) Toxic Toxic above threshold limit	Removal by precipitation
10.	Detergents; Soap and synthetic detergents	Domestic and industrial waste	Toxic	Physical treatment
11.	Specialised organic pollutants from pharmaceuticals industries Bio refractory organic pollutants Estrogenic substances	Pharmaceutical industrial waste	Persistent Toxics	Bio-treatment

Source: Environmental Science by S C Santra pp 237- 238

According to Goutam & Singh (2023), the DO level was found to be below 3.5 from Gorakhpur's Rudhauli-Bansi road to the Chhatai bridge. Due to increased river flow, there is a minor improvement in the quality of the water during the pre-monsoon period. However, in such a pollution instance, this is insufficient. This is the main issue with the Aami River because many fisherman and Dhobi people reside along its banks. These physico-chemical parameters—turbidity, colour, electrical conductivity, odour, TDS, COD, BOD, and DO—all demonstrate the current state of the water's declining quality. The lack of natural Sotas (the river's capacity to renew itself) and the discharge of sewage and industrial waste water into the river are the main causes of this state. Its ill condition is also indicated by BOD, COD, and DO levels, which are parameters that determine the quality and presence of aquatic living creatures. River water should not be used for domestic, drinking, or bathing purposes. It is not recommended for animals to drink this river's water. At its source at Bhatpurava, the river has class A quality, which diminishes as it approaches the Rapti River's confluence. This river's organic waste can be resolved with more continuous flow, but its sources of replenishment are gradually running out. Any water that this river receives along its course is used to dispose of trash from cities' sewage systems and industry. For this river to be ecologically viable, urgent revitalization efforts are required.

Studies carried out by Tiwari et al. 2021, clearly proved that the water body's color change is a clear sign of significant pollution. Fish that thrive on phytoplankton finds it difficult to survive in such a harsh environment since light is necessary for plant growth and photosynthesis, which in turn disrupts the growth of flora and fauna in aquatic environments. According to river water standards, river water shouldn't have any discernible colour. Therefore, it can be inferred that the Aami River is highly contaminated.

A distinct smell was also detected, indicating unfavourable conditions the River Aami was facing. According to the applicable class A water standards, there shouldn't be any offensive odour present within the body of water. As a result, it also shows that the River Aami is heavily contaminated.

One of the most important physical characteristics of an aquatic environment is its water temperature, which is influenced by the kinds and quality of nutrients present as well as the habitat that surrounds the body of water. It has an impact on the survival and growth of the plants and animals.
A rise in the water's temperature increases microbial activity and induces fish hormone changes, which in turn changes how the species reproduces and spawns. The kind of industrial effluents released as waste byproducts of continuous chemical reactions involving heavy machinery, heavy metals, and toxic chemicals is what causes the rise in water temperature.

pH data noted at different sites in River Aami showed variations for different sites with changes in season. When determining the quality of water, the pH is a crucial aspect. If the pH value of the water is higher than the neutral pH of 7, it indicates that it is contaminated by strong bases like NaOH or any other base. Additionally, pH data indicates if the contaminants released into the water body are basic or acidic.

Additionally, it was discovered that the number of total solids varied by site and season. Their level is higher than the reference limit set by the World Health Organization (WHO) and the Centre of Pollution Control Board (CPCB), indicating that industrial discharge from the chain of industries in the Gorakhpur Industrial Development Authority (GIDA) has severely contaminated the water. The level of total solids and total suspended solids limits the development of plants and aquatic life. These are solid waste items that are released by industries.

In order to keep aquatic life alive, dissolved oxygen is crucial. In any event, to sustain aquatic life, it shouldn't be less than 3.5 mg/l. But DO level was found to be least in summer season and winter seasons and higher concentration of DO was observed during rainy season.

BOD and COD levels of river water were also not found proper near the industries or where the industrial effluents were discharged.

Numerous significant discoveries have documented severe anaemia in fish as a result of bleached craft effluents from paper and textile mills, which cause an abnormal decrease in red blood cell counts due to frequent haemolysis and a decrease in total haemoglobin levels. Although the exact mechanism of haemolysis is unknown, some hypotheses contend that these complex chemical effluents lower cellular ATP and decrease oxygen consumption. Jaundice with a noticeable increase in bilirubin in blood plasma has finally been caused by hemolysis, which has decreased the total amount of haemoglobin. (abdallag.a., Ibrahim m.s., bahnasawym.h., abdel-bakyt.e ,1991);Nikinmaa m., oikaria.o.j, 1982; Everall n.c., Mitchell c.g., gromand.b., Johnson j.a.a, 1991.)

According to reports, fish C. carpio exposed to chlorpyrifos-ethyl showed a significant increase in leucocytes (leucocytosis) or white blood cells (wbcs) as a direct result of the excessivity of stress conditions. This, in turn, caused the immune system to be directly stimulated by the presence of pollutants in the form of industrial effluents in their aquatic environment (Okechukwu EO, Auta J, 2007).

Mill effluents of various types cause increase in MCHC and MCH and decreases RBC, WBC, Hb, MCV, and PCV.The haematological parameters demonstrate the dangerous nature of the mill effluents and are both valid and important. It is crucial to remember that the ongoing discharge of these effluents into the Ami River will undoubtedly make the scenario described in our paper worse in the future, as it may have a negative impact on the local flora and fauna as well as the residents. To address the significant issue caused by these sectors and enhance environmental protection in this region, a strategy involving rigorous law enforcement, public awareness campaigns, and routine monitoring is required.

Communities in the surrounding areas that economically rely on the river for agriculture and fishing have also been negatively impacted by the chemical and microbiological contamination that was caused by the effluent discharge that contaminated the Aami River (Afroz Z. and Singh A, 2014).

The most common way that fish receive pesticides is either direct skin absorption or, more commonly, through the gills while feeding. When consumed in any way, these substances—also referred to as xenobiotics—tend to result in a number of physiological and biochemical abnormalities, including alterations in the haematology of fish (Qayoom I, Shah FA, Mukhtar M, Balkhi MH, Bhat FA, Bhat BA, 2016),(Tiwariet al., 2021).Fish species are useful bioindicators of water pollution because of their capacity to absorb pollutants and exhibit a range of physiological, cellular, and even molecular reactions to them (Mohanty G et al., 2011). As a potential marker of physiological and pathological changes in fishery management and disease investigations, fish blood is being examined more and more in toxicological research and environmental monitoring (Zutshi B et al., 2010). Fish blood parameters have been investigated to evaluate fish health and uncover physiological adaptability. In fish exposed to a complex mixture of accessible pesticides and pollutants in water bodies, haematological parameters are increasingly being employed as indicators of the physiological stress response to endogenous and external alterations (Saleh YS, Marie MAS. 2016).

For the ecosystem to stabilize, for the environment to be protected, and for the intrinsic value of every species on the planet to be understood, biodiversity is crucial (Ehrlich, P.R. and E.O. Willson, 1991).In the catchment areas, streams and rivers are facing numerous problems due to anthropogenic activities throughout the globe.Degradation of the stream and surrounding ecology is a result of human activity's negative effects(Vijaylaaxmi, C. and K. Vijaykumar, 2011), which actually damages the structure and function of stream biota. The high levels of industrial pollution have an impact on the fish diversity of the Aami River. The findings show that pollution parameters like as biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), pH, and suspended solids all have a direct impact on fish diversity. Fish species diversity is studied by the methods given by Shannon-Weinerindex (H)Shannon, (C.E. and W. Wiener, 1963), Simpson Dominance index (D); Simpsonindex of diversity (1-D) (Simpson, E.H., 1949).

There are 18 fish species (Table. 2) in six orders, 11 families, and 17 genera. Cypriniformes were the most abundant species across all sites, followed by Beloniformes, Mastacembelida, Clupeiforemes, Symbranchiformes, and Perciformes, which were also present but, in less numbers, (Fig. 9). Fish species' distribution varies depending on environmental conditions. (Shukla P. and Singh A, 2013).

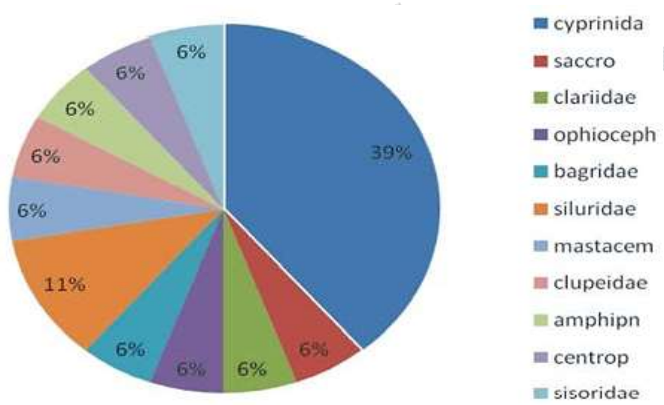


Fig 9: Percentage occurrence of fish families of Aami River, India

Table 2: Fish species in Aami River

SCIENTIFIC NAME	LOCAL NAME	FAMILY
Catla catla	**Bhakur**	Cyprinidae
Labeo rohita	**Rohu**	Cyprinidae
Labeo calbasu	**Kalbasu/Karaunch**	Cyprinidae
Puntinusconchonius	**Rani Machli**	Cyprinidae
Cirrhinus mrigala	**Nain**	Cyprinidae
Chela atpar	**Chalani**	Cyprinidae
Amblyphryngodonmola	**Mauna Machli**	Cyprinidae
Chanda hama	**Gurda**	Centropomidae
Amphipnous	**Kuchiya Machli**	Amphipnoidae
Macrognathus aculeatus	**Bam Machli**	Mastacembelidae
Channa punctatus	**Girai**	Ophiocephalaidae
Bagarius bagarius	**Goonch/Baghar**	Sisoridae
Ompok bimaculatus	**Pabda Machli**	Siluridae
Gudusia chapra	**Suiya**	Clupeidae
Wallago attu	**Lachi**	Siluridae
Mystus bleekeri	**Mastus**	Clariidae
Clarias batrachus	**Magur**	Clariidae
Heteropneutes fossilis	**Singhi**	Saccobrachidae

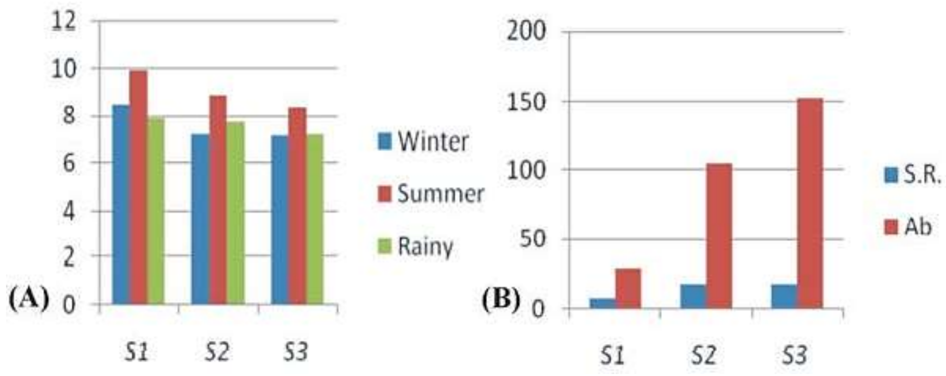


Fig 10: Effect of (A) pH of Aami River compared with (B) species richness and abundance.

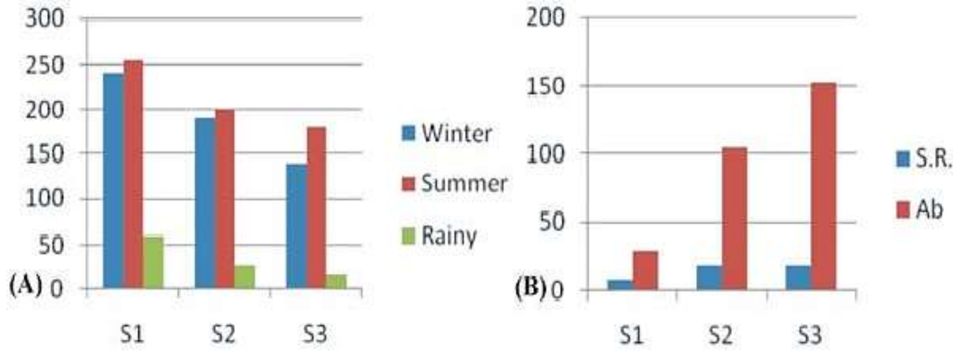


Fig 11: Effect of (A) BOD of Aami River compared with (B) species richness and abundance.

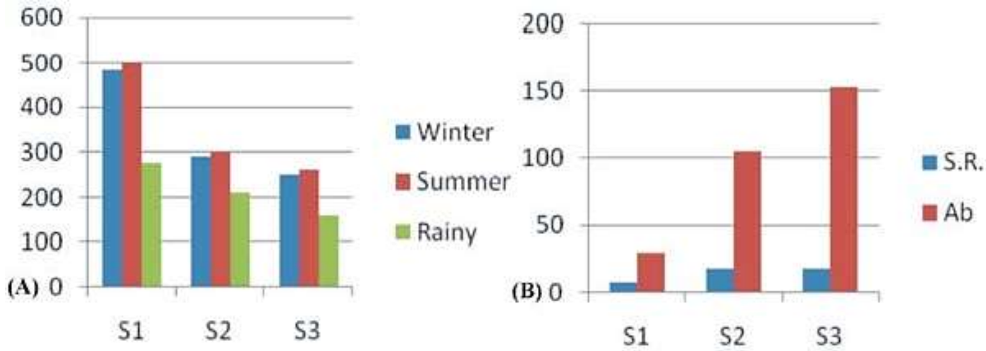


Fig 12: Effect of (A) COD of Aami River compared with (B) species richness and abundance.

The findings of the research revealed that fish variety in the study area is decreasing as water pollution increases. Reduced fish diversity gradually reduces native species' fish production, leading to the extinction of some species.

Water contamination and altered phytoplankton growth are caused by industrial wastewater. Determining the contamination caused by industrial wastewater merging into the river may be made easier with the identification and diversity of these species. Recent investigations examined the discharge of treated wastewater straight into the Ami River.

Being the foundational component of the food chain for all aquatic organisms, phytoplankton are important to the environment (Mishra SM., 2001). One key sign of human influence with the natural ecosystem that could result in an aquatic decline in biodiversity is the variety of phytoplankton and zooplankton (Isshad Ahmad, Ahangar Mohammad and Faooj Mir.2012). Other biotic groups in the water body and water quality regulate the phytoplankton's population and variety. Large volumes of solid waste from nearby communities, chemical fertilizer and pesticide residue, petroleum products from ships, launches, cargo, boats, untreated sewage, etc., are all routinely dumped into these rivers. The development of aquatic plants and animals is slowed down by these contaminants (K. Kaewsri et al. 2012). Seasonal analyses of the phytoplankton in the Ami River water were conducted, and the phytoplankton density was determined. Five classes of phytoplankton, including Bacillariophyceae, Chlorophyceae, Cynophyceae, Dypnophyceae, and Euglenophyceae, were found in the Aami River according to the research done in the Natural Product Laboratory, DDUGU, Gorakhpur (Fig. 13).

Bacillariophyceae- With 15 species out of 45 reported in the phytoplankton diversity, Bacillariophyceae was found to be the most prevalent category. Amphora, Diatom, Fragilaria, Navicula, Nitzschia, Pinnularia, and Synedra were the most prevalent species. According to the study, the population peaked in the winter and declined during the wet season. As per the study, the presence of Amphora, Diatom, Fragilaria, Gamphonema, Navicula, Nitzschia, Pinnularia, and Synedra may be attributed to their ability to adapt to their surroundings and endure adverse conditions. Additionally, these phytoplankton species can serve as a marker of organic pollution in the Aami River. Eutrophication was linked to the high growth of Nitzschia sp. in the winter and Navicula sp. in the summer. This data supported the conclusion that Bacillariphyta development was enhanced by tolerance to various types of pollution (Abdel-Hamid, O.M.and Galal, T.M. 2019). Additionally, this might be a blatant sign that the Aami River is heavily contaminated due to human activities like industrial effluents, which could have a detrimental effect on the diversity of phytoplankton.

Chlorophyceae- During the current investigation, a total of 14 species of Chlorophyceae were found in the Ami River, making them the second most numerous categories of phytoplankton. The dominating species in the summer, lowest in the rainy season, and average in the winter were determined to be Ankistrodesmus, Cosmarium, Spirogyra, Ulothrix, Volvox colony, Zygnemagiganteume, and Zygnemaczurde sp. Zygnemagiganteume and Zygnemaczurde are the two most prevalent species in the Chlorophyceae domain. The findings indicate that the Spirogyra, Zygnemaczurde, and Zygnemagiganteume species are able to endure in the Aami River despite adverse conditions.

Cynophyceae- Both the number of general species and their abundance placed Cynophyceae in third place. There have been eight species identified in the Ami River overall. Summertime saw the highest diversity, while the wet season saw the lowest. Among these, the major species are Anabaena, Aphanizmenon, Nostoc, Microystis, and Spirulina. The oscillatory The Ami River is dominated by Phormidium. Indicators of sewage pollution in the Ami River include Oscillatoria, Microystis Spirulina, and Anabena. It has previously been It is well known that some species cause water blooms in contaminated areas. Anabaena, AphanizmenonMicroystis, Oscillatoria, and Phormidium are the most important genera that cause blooms; they can produce a variety of cyanotoxins, including microcystins and anatoxins, and occasionally these blooms can be enormous.

Dypnophyceae- With six species identified from the Ami River, the Dypnophyceae family was rated fourth in terms of abundance. The summer season saw the maximum number of Dypnophyceae, while the rainy season saw the lowest. It was discovered that Gymnodonium and Ceratiumhirndinella were the prevalent species.

Euglenophyceae- According to reports, the Ami River's lowest species is Euglenophyceae. During the study period, only two species were documented. Reports of Euglenophyceae are highest throughout the summer and lowest during the wet season. In the summer, Euglena sp. has been documented in the Ami River, although it does not occur during the wet season. In the Ami River, phacus sp. is most common in the summer and does not occur throughout the winter. Members of the Euglenophyceae family were detected in the fewest numbers when compared to other algal types. Dilution by the rainy water combined with poor climatic conditions may be the cause of the low phytoplankton density observed during the rainy season.

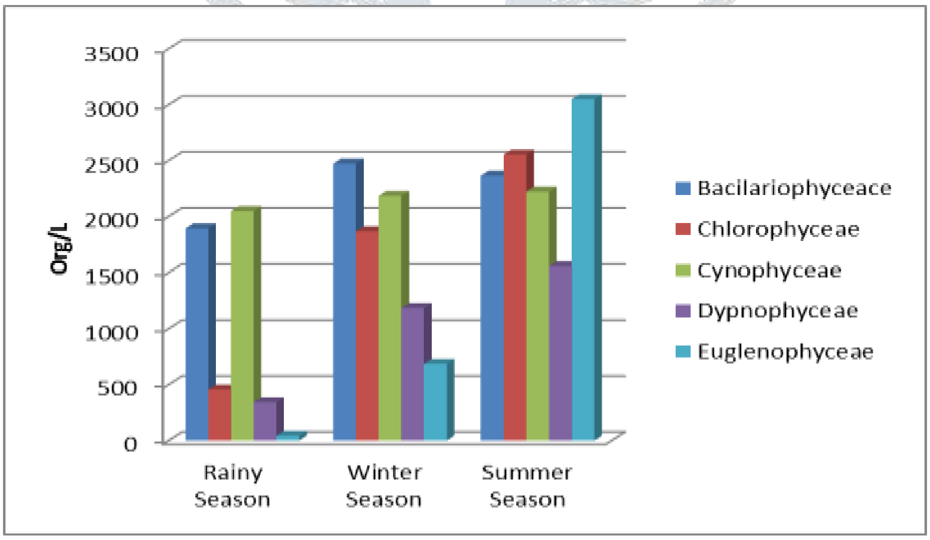


Fig 13: Seasonal Variation of Phytoplankton Diversity in Aami River

Polluted water has been shown to be extremely detrimental to the aquatic ecology and phytoplankton diversity. Euglenophyceae were more sensitive to the pollutants, but Bacillariophyceae were found to be prevalent in the study because they seemed to be best suited in the polluted ecosystem. Phytoplankton abundance was found to be lowest close to the sources of pollution and to be somewhat less polluted overall. The Ami River ecosystem is currently in an endangered state as a result of an imbalance in productivity brought on by wastewater discharge.

V. WATER TREATMENT PLANT

Our continuous efforts to supply safe drinking water and efficiently manage wastewater are intimately related to the history of water treatment. Clean water has been successfully supplied to cities by large-scale water treatment facilities. Although these enormous systems are necessary for managing large volumes of water, they are expensive. The demand for these massive systems has significantly expanded as the population has grown. Long-distance water transportation is extremely difficult, and infrastructure in isolated and rural areas presents difficulties. More adaptable methods of water treatment are therefore the ideal option. Water can be treated in industries, residences, or commercial buildings with small, nearby water treatment facilities. Where large systems are impractical, this is really helpful. Thus, the necessity for these smaller, regional water treatment facilities has increased. According to Zhao et al. (2023), the wastewater industry needs energy efficiency and savings to lower operating costs and environmental effect.

A significant infrastructure project designed to address the city's wastewater management concerns is the 30 MLD (million litres per day) sewage treatment plant in Gorakhpur. Gorakhpur's continued expansion and development have made managing sewage and wastewater a top priority due to increased urbanization, population growth, and industrial activity. Effective sewage treatment is necessary to protect water resources, maintain public health, and promote sustainable urban expansion. The significance of Gorakhpur's 30 MLD sewage treatment plant is investigated, along with its operations, processes, challenges, and broader implications for wastewater management in urban India.

Three separate levels of onsite wastewater treatment plants—community, communal, and household—are thought to be spread across Gorakhpur. Different types of technologies are grouped in multiple systems at each of these levels.

The last three years have seen a concentrated effort to install on-site wastewater treatment plants in Gorakhpur city. Numerous technologies that are appropriate for on-site wastewater treatment facilities have been created. To offer detailed technical information regarding the onsite wastewater that is currently present, a questionnaire has been created and distributed to various locations

plants for therapy. Over the course of six months, two on-site wastewater treatment facilities at various levels—household, collective, and community—were dispersed around various locations and assessed. One factory used the activated sludge method at the home level.

and up-flow gravel filters were employed in two plants. Together, the two facilities employed a prolonged aeration process; one plant used polishing sand filters after aerobic and anaerobic gravel filters. Gorakhpur’s 30 MLD facility contributes significantly to the city's increasing demand for effective wastewater management, which is essential for environmental preservation and public health.

In addition to controlling sludge, Gorakhpur's 30 MLD STP generates biogas, a renewable energy source, which helps the city achieve its sustainability objectives. Finally, environmental repercussions such as the disposal of sludge from biological treatments or concentrated brine from reverse osmosis systems provide challenges to waste management and environmental sustainability. These byproducts' contribution to pollution could negate some of the environmental benefits of on-site water treatment if proper disposal or recycling practices aren't followed. These systems offer workable solutions to issues with water scarcity, pollution control, and resource sustainability in general, but they require robust legislative backing. If regulations are broken, the goal of having a clean water supply will never be realized.

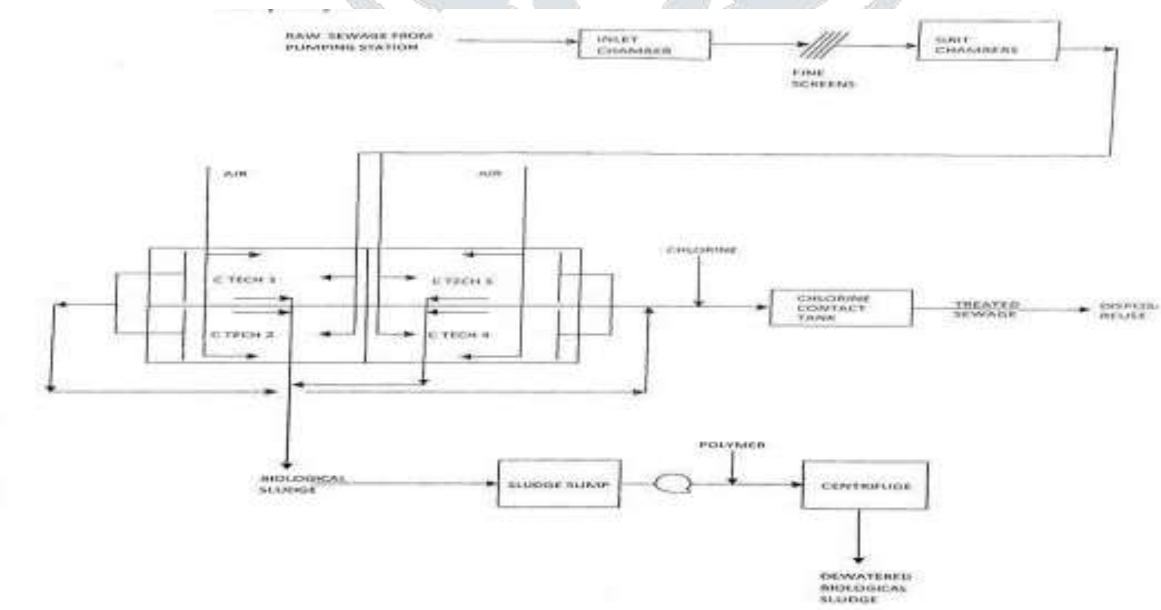


Fig 14: Flow Chart Of 30 MLD Plant (Source- STP Gorakhpur)

Future Trends and Innovations

The field of water treatment is quickly changing due to the influence of Artificial Intelligence (AI) and Machine Learning (ML). Through constant data analysis, failure prediction, and real-time operational adjustments, AI-driven processes may optimize water treatment systems. Improved water quality, lower operating costs, and increased efficiency result from this. In membrane filtration systems, for example, AI can be used to track fouling levels, preventing blockages and enhancing long-term performance. By using nano-filter membranes to eliminate even the tiniest contaminants, such as viruses and heavy metals, nanotechnology provides enhanced filtration capabilities. These materials use less energy and are more efficient than conventional filtration techniques. Additionally, nanomaterials such as graphene oxide are being investigated for their potential in removing contaminants and desalinating water.

Smart water systems automate and remotely monitor water treatment processes by combining Internet of Things (IoT) devices. These technologies enable real-time data collection, which improves operational precision and enables predictive maintenance. IoT sensors can detect anomalies in water quality and system performance, warning operators so they can take corrective action before a failure occurs. AI and IoT enable self-regulating systems that maximize sustainability and water efficiency. Capacitive deionization is one of the electrochemical water treatment methods that is gaining popularity. Using an electric field to extract salts and other impurities, CDI is an energy-efficient method of desalinating and cleaning water. This technique is especially appealing in places with limited water supplies since it can operate at a fifth of the energy cost of reverse osmosis.

VI. CONCLUSION

The necessity for immediate action to improve the river's water quality and revitalize its aquatic environment is acknowledged. This calls for, on the one hand, proper handling and disposal of industrial wastewater and, on the other, consistent river water monitoring to guarantee that the "River stays a River." According to Amar Ujala newspaper, during the rainy season of the year 2024 the river's condition was a bit stable but on 30th October unexpectedly, large amount of industrial effluent was dumped into the river water by any industry. As a result, the fishes died in large number and were seen floating on the water. The fishermen took out the dead fish floating on the river using their nets and dried them on the river bank and sold them in the market. The matter reached the government level, then the Pollution Control Board sent its employees to collect samples of the river water. The employees who went to the spot also saw that it had become difficult to stay on the river bank due to the foul smell. Dead fish were lying everywhere.

Regional Pollution Control Officer Ajit Kumar Suman said that the notices will be sent to factories on the river bank and a reply will be sought. Polluted water from drains and factories is dumped in the river. In June, when the temperature is more than 40 degrees centigrade and the plants found at the bottom of the river also use oxygen, then the dissolved oxygen will be less, but there is no special effect of this in the figures. Aquatic organisms do not die when the amount of dissolved oxygen is 4 milligrams per litre or more. This will happen only when the dissolved oxygen falls below 3, whereas the figures of the river are much better than this. Therefore, there is no co-ordination between the data provided by the department and the current condition of the river.

With the study findings it can be estimated that the river condition is not upto the mark. The polluted river is becoming a reason for the decrease in the population of fishes as well as planktons which would ultimately lead to extinction of certain species.

VII. ACKNOWLEDGEMENT

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