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Revitalizing waters: Advanced treatment technologies for cleaning polluted aquatic ecosystem: A review

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Abstract
To live a sustainable existence, one must abide by environmental management regulations, which place a premium on pollution prevention and cutting-edge treatment methods. Water basins afflicted by malmsey, the implementation of control measures and cutting-edge technologies will contribute to the real-time regeneration of the supply of high-quality water. Utility firms would benefit greatly from the control tactics and cutting-edge technologies for managing water pollution, as they would help guarantee that all Countries have access to sustainable, dependable, and drinkable water supplies for both the present and future generations. Artificial intelligence (AI)-driven decision-making tools facilitate the most efficient application of diverse treatment technologies, including chemical precipitation, membrane technology, adsorption, ion exchanges, electrokinetic processes, and Phyto- remediation, in the removal of pollutants from impacted water bodies. The people have benefited from the industrial sector's recent rapid development, but it also produces large amounts of wastewater that are harmful to humans and the environment since they contain heavy metals, hydrocarbons, nitrogen, and phosphorus. As industrial effluent treatment technology advances, new approaches focusing on hybrid systems that are efficient in recovering resources from effluent in a cost-effective, time-efficient, and feasible way are emerging.

Keywords: Aquaculture, wastewater treatments, industry, revitalization

Introduction

Aquaculture water management is critically needed to reduce its effluent discharge and freshwater usage, therefore minimising environmental impacts. Water, is one of the elements that allows life to exist on Earth (Orooji *et al.*, 2020) [35]. Around the world, water is widely exploited as a resource for social and commercial purposes (Hassandoost *et al.*, 2019; Karimi-Maleh *et al.*, 2020) [11, 18]. Only 2.5 percent (or roughly 71 percent) of the world's total water content is pure water (Bhat *et al.* 2014) [5]. Fresh water is essential to life and the ecosystem. Lakes, ponds, rivers, groundwater, and streams are examples of freshwater resources (James *et al.*, 2002; Xu *et al.*, 2020) [16, 54]. The remainder is found in glaciers and unsuitable groundwater sources; only around 1% of it is usable by people or business. However, because of the ongoing industrialization and population growth, these resources are running out. Climate change, inter annual climate variability, and the use of fresh water for energy production are further factors contributing to freshwater scarcity and depletion. Fresh water scarcity has emerged as a major environmental concern (Murshed and Kaluarachchi, 2018; Teodosiu *et al.*, 2018) [30, 49]. According to United Nations (2007) FAO assessment, there could be some 1.8 billion people on the planet who live in areas where there is absolute water scarcity, and two thirds of all people may experience water stress. Recovering water from current wastewater or locating alternative water sources for human use are essential to solving the issues associated with water scarcity.

The need to develop sustainability has arisen as a result of the ongoing advancements in various types of civilization, industry, and urbanisation. This is necessary to ensure that people live longer, healthier lives. Long, healthy, and happy lives are at risk because of the numerous human activities that introduce pollutants hazardous elements or substances into our ecosystem. The goal of this paper is to address environmental sustainability challenges by utilising advanced treatment technologies and effective control measures to address pollution incidents in Ghana's river basin.

Living a better and sustainable life is associated with adhering to environmental management regulations, where pollution control and advanced treatment technologies are imperative. Rising levels of water pollution caused numerous rivers in Africa, Asia countries (such as India, Sri Lanka) and Latin America to experience a decline in water quality starting in the 1990s. According to economists Gene Grossman and Alan Krueger, this kind of pollution exhibits an inverted U-pattern as development proceeds. There is a claim that as nations develop and become more industrialised, pollution will rise. This is because pollution levels rise in response to economic expansion. According to UN-Water, the difficulties associated with pollution and its consequences on the management of water quality are expected to worsen due to a lack of precise data. It is more significant and not hyperbole to state that, given the extent of pollution and the ongoing deterioration of water quality, if action is not taken, particularly in the areas of water pollution control and revitalization, water quality is expected to worsen and pose greater risks to human health, the environment, and sustainable development in the ensuing decades.

Certain actions made by citizens for material comfort or prosperity, as reported by (Damania *et al.*, 2019) [8] and, harm the ecosystem. Therefore, in order to lowest the trend and perhaps create a better environment, cleaner policies and technology must be adopted. The best way to enhance the environment is through expansion, as explained by the environmental Kuznets curve. Significantly, both high- and low-income nations' rural populations are becoming increasingly concerned about the quality of their water. Because of this, it is troublesome to ignore the potential that arise from revitalization, the application of sophisticated technology, and water pollution control measures, particularly in light of the situation in many countries, where the largest source of water pollution has happened. This is due to mining in large river basins' watercourses and bodies of water, especially the river basin. The United States' Environmental Protection Agency (EPA) divides water pollutants into six groups, according to (Ibrahim *et al.*, 2021) [1], plant nutrients, biodegradable waste, heat, sediment, hazardous and toxic chemicals, and radioactive contaminants. However, the cost of damage is usually employed to determine the direct price of environmental degradation brought on by water contamination. The costs of prevention, such as the infrastructure expenses to lessen damage and the maintenance cost approach, are used to estimate the cost of damage. However, averting the harm has advantages as well, such as avoiding productivity losses brought on by alterations in water quality. It is critical to find a balance between the costs of water body pollution and the economic benefits of cash creation from gold mining.

The high expense of treatment brought on by the high pollutant prevalence was one of the numerous reasons given for the intended 334% upward adjustment. Although there are several methods to do the crucial task of estimating pollution costs, the cost-based approach is a well-liked method that provides three options. These three costs are associated with abatement, restoration, and structural repair. Abatement costs are the most often used metric for estimating the costs of applying treatments to prevent water pollution, restoration, and abatement. The most popular method of measuring the costs of adding solutions to avoid water pollution is called abatement costs. However, (Braimah *et al*., 2022) [56] believes that if water pollution is controlled, costs and tariffs will go down. For this reason, addressing Ghana's water pollution issues through the use of cutting-edge technologies, revitalization techniques, and the application of strong rules and legislation is essential. Additionally, the expenses incurred are referred to as structural adjustment costs when the economy is reorganised in terms of production and/or consumption patterns. More significantly, structural adjustment costs frequently include intricate modelling of the entire economy and are specifically implemented to lower water pollution and other types of environmental degradation to a recommended level. The cost of bringing a damaged ecosystem or water body back to a usable state is measured by the third factor, restoration cost.

Technology for reducing water pollution and revitalization: Water is a basic element that all living things require for growth and survival, but a significant challenge is figuring out how to create the right environment in order to offer enough clean, inexpensive, and safe water to meet global demand. 96.5% of the world's water is known to be in the seas, where it cannot be used for any purpose domestically unless it is treated. Only 0.07% of water is suitable for human consumption and other uses (freshwater); the remaining 3.5% is made up of surface and groundwater, as well as other substances found in glaciers. If water is colourless, odourless, and tasteless and can be used for all household and other uses, it is considered drinkable. But water is considered filthy if it lacks these qualities (Kaushik *et al.*, 2019) [20]. Water pollution is a problem in both developed and developing nations, albeit the degree of contamination varies depending on the kinds of pollutants caused by human activity. This leads to a classification of water pollution, which reduces the amount of Earth's available potable water. These contaminants are divided into various categories and comprise both point and non-point source discharges. Industrial discharges pose a threat to the quality of the water and alter its properties.

Mapping Cultural Assets: The River Basin and its tributaries supply water to forty-three administrative districts. As a result, it is used for a variety of purposes, including irrigation, agricultural, and household use. However, the water resource in the basin is under more stress due to the clearing of forest for mining operations, other infrastructural projects, and habitations. The river serves different cultural purposes in different communities, therefore it's important to come up with a strategy that will reduce pollution, offer water management value and security, and address all of the water body's cultural roles across all populations. After careful examination, UNESCO determined that a research method or instrument like cultural mapping was essential to protecting the world's tangible and intangible cultural heritage.

Water Usage in Relation to Values: A control plan for transformation is just as important as the regulations governing land ownership for mining in and around this water body, which also illustrate the process of allocating and distributing water within the river confluence. Water usage allocation, however, has not proven particularly successful in lowering conflicts or controlling pollution of these bodies throughout the region, whether in the form of concessions (which is the most used mechanism in the region) or water rights (which is a legal right granted to property owners on ways to use water bodies close to their lands). Once more, every community indigenous or not has unique knowledge and moral standards.

Additionally, different stakeholders have varying relationships with water bodies, the environment, and social groupings. As a result, there may be variations in usage, upkeep, and security measures. In this instance, from one community to the next. Thus, it is necessary to incorporate "relational values," which will support a pluralistic approach and assist in addressing varied values in regard to water bodies (Parsons *et al.*, 2019) [36]. This is because it is obvious that values will range from place to place due to the many cultures in these communities, since the river and its tributaries form an important source of water supply for many of the villages in the basin.

In a geographic information system (GIS), overlay analysis: In addition, the importance of mining operations and the hotspot nature of illegal mining-related water pollution and its related effects need to be thoroughly confirmed using overlay analysis in GIS in the research area (McDonnell *et al.*, 2008; Srinivas *et al.*, 2018) [29, 48]. Remote sensing technologies will provide highly efficient means of observing the distribution, quality, and seasonal dynamics of earth surface water bodies. Water bodies can be distinguished from other terrestrial objects by optical remote sensing due to their unique properties, which may result in a reduced water reflectivity (Bie *et al*., 2020; Huang *et al*., 2018) [6, 13]. Three different techniques for extracting water bodies from optical remote sensing pictures have been devised, taking into account the properties of water bodies. These consist of the following three methods: first, extracting water bodies using indices; second, extracting water bodies without using indices; and third, utilising a different combination of indices to delineate water (Bie *et al*., 2020) [6]. By identifying dangerous materials or blooms (pollutants) and the effects of changing land use and cover due to illicit mining, the optical remote sensor in the basin will employ satellites to gather data on the water quality. This will assist in the development of a purification strategy or policy by the government and water managers, depending on the data generated by the optical remote sensor.

Cutting-edge techniques to reduce water pollution: The literature discusses a variety of approaches for controlling water pollution, such as biological degradation, chemical breakdown mechanisms, and physical separation. Adsorption, phytobiological remediation, ion exchanges, electrocoagulation, electrokinetic processes, phytoremediation, nano phytoremediation, chemical precipitation, and membrane technology are a few of the most widely utilised control methods today (Alka *et al*., 2021) [1]. Furthermore, the latest developments in nanotechnology are considered to be a practical and affordable solution that may effectively address the range of issues that have arisen from the use of existing treatment techniques.

Adsorption: Adsorption is one of the most well-known methods of treating water. It uses activated carbon as a universal adsorbent to remove various contaminants by absorbing dangerous metal ions from wastewater, the surface, and the ground (Gupta *et al*., 2013) [10]. Adsorption is mostly utilised to remove or reduce the different impurity concentrations from water or wastewater that has dissolved pollutants, which tend to colour the water (Alka *et al*., 2021) [1]. In adsorption technology, activated carbon is a common adsorbent that is utilised to remove various contaminants. Adsorbents have been researched and employed as a treatment and/or control technology, as mentioned by (Alka *et al*. 2021) [1], to obtain an ecologically acceptable substitute meant to eliminate the efficiency of pollutants which originate from the fact that the technology is not self-monitoring. To remove arsenic from effluents, for instance, (Nath *et al*. 2019) [31] showed how biochar produced from rice husks was permeated with iron oxide. The effects of pH, adsorbent dosage, adsorbate dosage, and contact time on the adsorption process were investigated by biochar modelling. The potential for developing innovative water treatment systems through the use of biochar derived from rice husks to remove arsenic through iron oxide penetration seems encouraging.

Application of artificial intelligence (ai) in adsorption: Artificial Intelligence (AI) is a valuable tool in the construction of frameworks for the rehabilitation of water bodies that have been contaminated by illicit mining activities, as it can optimise and analyse relationships among numerous aspects. Due to the extensive use of mercury in the extraction of ores from lands, underground mines, and waterbodies, the illicit mining industry tends to harm the environment (Nyarko *et al.*, 2020) [27]. Because mercury is less expensive, easier to use, and more effective than other extraction techniques, miners favour it for use in operations. Mercury residue finds its way into surface waterways, soils, and the environment as a whole. Adsorption is the safest method for removing metalloids and heavy metal contaminants from surface water and/or separating the two. The goal of the adsorption process is to use an absorbent material that can remove a large number of the dissolved contaminants from the water body. The efficiency of adsorption is dependent on a number of process parameters, including temperature, heating rate, adsorbent surface area, dose, initial concentration, particle size, contact time, and pH value. Consequently, it is necessary to take into account a development model that calls for more experimental research.

Gaps and difficulties in utilising adsorption technology: Adsorption's drawbacks include its poor ability to adsorb large concentrations of contaminants, its low specific surface area that is not self-monitored (Alka *et al*. 2021) [1], its loss of adsorbent, and the expensive expense of regenerating adsorbent.

Technology Raodmap: To increase its effectiveness, adsorption technology can be used in conjunction with other removal techniques.

Exchange of ions: Using a method called physicochemical ion exchange, which draws its mechanism from solid phase ions with the same ion numbers seen in contaminated water, the majority of arsenic contaminants are eliminated. In other words, undesirable ions in the water will just be substituted for a different ion. Ion exchange uses electrostatically trapped ions to lessen water hardness and remove impurities from waste or contaminated water. This technology's drawback is that it's highly costly and frequently requires rejuvenation procedures to get rid of all contaminants. But because it removes and recovers metal objects for instance, achieving a removal efficiency rate of 97.9% in the pH range of 3.5 to 7 its benefits are substantially greater (Karakurt *et al*., 2019) [17]. SDG 3 and SDG 6 may be realised through the advancement of ion exchange technology, which removes and recovers metal objects and enhances human health and well-being while guaranteeing access to clean water and sanitary facilities. Numerous health concerns, such as neurological diseases, cancer, and reproductive problems, can be brought on by exposure to heavy metals.

On the other hand, ion exchange, a method of eliminating heavy metals from water sources, can enhance human health and access to clean water.

Applications of artificial intelligence (ai) in ion exchange: Ion exchange is one of the finest methods for removing arsenic contaminants during the exchanges between a solution and an insoluble solid. Ions can be recovered and removed using this technique. Ion exchange, on the other hand, is used to simply replace undesirable ions from the water and replace them with relevant ions in water treatment caused by unlawful mining. Advanced AI technology can be used for this. This technique provides a practical means of isolating, purifying, and eliminating pollutants that contain ionic compounds. Since illicit mining activities frequently contaminate water, hazardous heavy metals like lead (Pb) and mercury are removed from it using ion exchange resins during water purification. For example, ANNs and ANFIS are AI models that can be used to modify the ionic content of water. An ion-exchange resin would thus permit water to pass through it, exchanging ions with comparable charges in the process. This would also aid in the more efficient removal of calcium and magnesium ions (Ghule *et al.,* 2023) [22].

Gaps and difficulties in utilising ion exchange technology: The high operating expenses associated with ion exchange technology represent a significant drawback. It is also not self-renewing because it needs constant renewal. Due to the high operating expenses, this method could not be viable for big, heavily contaminated water bodies like the Ganga River in impoverished nations like India (Olmos *et al*., 2019) [24].

Technology schedule: Before the filtrate is passed through the resins, organic molecules can be eliminated using pre-treatments such filtration because the resins used in this procedure are expensive.

Electrokinetic procedures or techniques: Electro kinetic technology explains the flow of ions and other particles that are comparable to one another under an electric field, as well as the transfer of water and other fluids (Pamukcu *et al*., 1993) [53].
In particular, this technique aids in the extraction and separation of charged particles and contaminants from soil, water substances, and soil by electrical adsorptions, hence aiding in the control of water pollution. However, due to the risk of heavy metals and its challenging dissolved phases, the electro kinetic technique is insufficient for the removal of arsenic contaminants (Alka *et al*. 2021) [1].

Application of artificial intelligence (ai) in electrokinetic procedures or techniques: The majority of the water bodies in Ghana's southwest are contaminated by illegal mining activity. The pollution resulting from these illicit mining activities, sometimes known as malmsey, include heavy metals like lead and mercury as well as other ionic compounds. The electro kinetic method is essential for cleaning up contaminated waterways. When compared to other procedures, electro kinetic techniques have shown to be especially effective and environmentally benign. He maintained that the primary benefit of the method is that, in theory, electrons are the only reagent needed for it to work. However, these electrolytes are required to achieve a noticeable effect in a reasonable amount of time and with sustainable energy use. In situations where the applied electric fields would readily reach contaminants in the surface water or beneath, the method, for example, provides for improved efficiency and can be administered in both the original condition and the temporal state. Similar to this, even though the polluted soil would not be readily permeable, the electro kinetic remediation technology (EKRT) approach was used to apply an electric potential gradient to create low electric current across a segment of the soil according to (Vocciante *et al*. 2021) [50].

Utilising electrokinetic techniques presents gaps and challenges: The possibility of a high pH during operation can hinder the removal of heavy metals. Arsenic is one example of how the method converts heavy metals into their mobile phase, making treatment more challenging. During the process, there is also an increase in heavy metal movement (Alka *et al.*, 2021) [1].

Technology Schedule: Combining electro kinetic technology, which is still in its infancy, with other technologies, such permeable-reactive barriers, will increase its effectiveness.

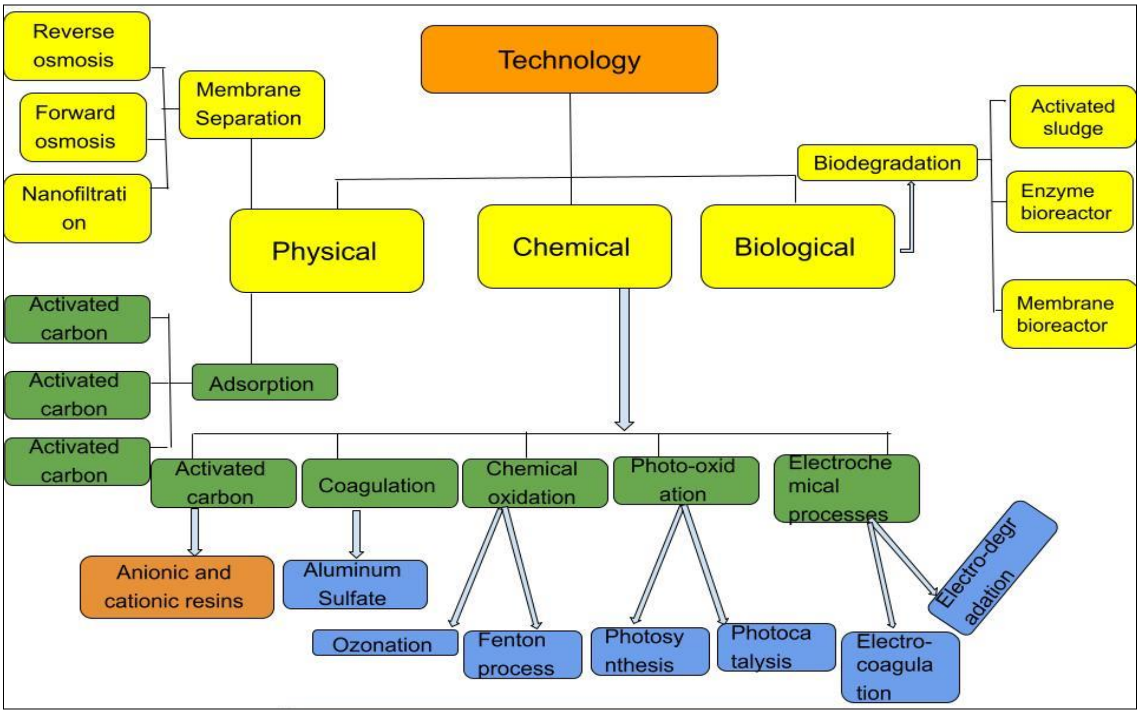

Fig 1: Waste water treatments technology

Chemical Precipitation: This can be described as a process of solidification in which components dissolved in water change into solid particles. Chemical precipitation is the most widely used method for handling contaminants including wastewater and arsenic. As a result, this procedure helps to eliminate anions such phosphate, cyanide, fluoride, and phenols precipitate and also changes dissolved arsenic into low solubility compounds (Wang *et al.,* 2005) [52]. For instance, chemical precipitation has also been used to treat gold-mining waste using two-stage nano filtration for both arsenic and calcium, as mentioned by (Alka *et al*. 2021) [1].

Application of artificial intelligence (ai) in chemical precipitation: Artificial Intelligence (AI) has the potential to be utilised in chemical precipitation processes to help eliminate heavy metals, like lead and mercury, and arsenic pollution that are a result of illicit mining activities in water bodies. As a water treatment measure, chemical precipitation techniques are used to turn soluble contaminants in water bodies into insoluble form. In order to estimate future precipitation based on observations, artificial intelligence (AI) based approaches can be utilised to indicate the contaminations in the precipitated particles. In order to do this, atmospheric reanalysis and precipitation datasets from several satellites are combined. For instance, improved precipitation projections across the upper Blue Nilebasin were produced using AI approaches (Khan *et al*., 2021) [21]. AI will therefore assist in forecasting the heavy metal parameters in the precipitated solid particles for upcoming ion exchange or adsorption procedures.

Utilising chemical precipitation and gaps presents challenges: Large amounts of less dense sludge can be produced when hydroxide is used as a precipitant. Dewatering and eventually disposal procedures are hampered by this. The fact that complex chemicals in a solution may prevent metal hydroxides from precipitating presents another difficulty. When metal sulphides are present, colloidal precipitates develop, which lead to filtration issues following precipitation.

Technology Schedule: The procedure can be enhanced by using ion exchange, nanofiltration, and chemical precipitation together. The problem of satisfying the process's environmental discharge restrictions can also be eliminated with the introduction of chelating agents (Wang *et al*., 2011) [9].

Phyto-Bial Cleanup: Phytoremediation is aided by microorganisms (bioremediation) in a process known as Phyto-Ballistic remediation [Manoj *et al*., 2020; Niazi *et al.*, 2017) [26, 32]. Thus, Phytobial remediation benefits plants by raising stress tolerance and detoxification, as well as by improving nutrient availability through the supply of phytohormones, as indicated by (Kaur *et al*. 2018) [19]. The mechanism makes use of interactions between microbes and plants to promote plant sequestration. Despite its existence, phytobiological remediation is low-cost and highly sustainable since it preserves the environment while generating long-lasting, effective processes.

Application of artificial intelligence (ai) in phytobial remediation: Utilising bioremediation potentials is crucial to resolving environmental challenges because arsenics are toxic to water bodies. According to (Roy *et al*. 2015) [43] state that two novel techniques with cutting edge uses for long-term mitigation of the arsenic epidemic are phytoremediation and bioremediation potentials. This is due to the fact that they both aid in the extraction of arsenic from groundwater and soil. Artificial intelligence (AI) approaches can be used as cutting-edge measures to harness the removal of arsenic from water bodies utilising the Phytobial remediation process. These techniques involve tracking the growth of plants in various contaminated soils and groundwater. For instance, heavy metal hyperaccumulator plants were widely used in the past to extract heavier metal concentrations. Plant growth promoting rhizobacteria (PGPR) has now been shown to assist remediate contaminated environments and lessen heavy metal issues (Asad *et al.,* 2019) [2]. To track plant growth, a variety of cutting-edge remote sensing tools, including cameras, sensors, and related contemporary technologies, can be used as AI devices. Furthermore, (Singh *et al*. 2022) [57] reported that AI techniques were applied to a variety of tasks, including the detection and monitoring of heavy metal mobility, bioavailability, seasonal change, and plant response.

Obstacles to use phytobial remediation and deficiencies: Phytobial clean up takes time since it needs to give the plants enough time to grow before they can start absorbing heavy metals from contaminated sources. Plants' roots are particularly susceptible to metal concentrations, which can result in stunted or sluggish growth and, ultimately, render the plant incapable of absorbing metals (Alka *et al*., 2021) [1].

Technology Shedule: To solve the aforementioned difficulties, the plant/root system can be improved through the application of nanotechnology and genetically modified bacteria. To restore the contaminated water body in the Ghanaian basin, rules that forbid illegal mining in the catchment region should be put into place and enforced. Phytobial treatment should also be used.

Membrane Technology: Selective barrier holes are used in membrane technology to accept and reject items from the influent water (Singh *et al*., 2015). Although there are many other kinds of membrane technology, reverse osmosis, ultrafiltration, nanofiltration, and microfiltration are the most often used ones. Implementing a potential gradient, unwanted components are extracted from the feed solution. When compared to other membrane technology forms, nanofiltration has been demonstrated to be more effective at removing minuscule unwanted solutes. For instance, it is well known that the closed membrane reactor system uses membrane technology extensively for environmental water purification treatment. The technology was used in an open natural water system using a gravity-driven biomimetic membrane (GDBM) by (Zhu *et al.* 2020) [55]. This is a proven specialised use of membrane technology that converts it from an environmentally friendly method of treating water to an extremely effective and economical method of treating water ecologically in an open natural water system. (Petrinic *et al*. 2015) [38] provided yet another real-world example, demonstrating how ultrafiltration and reverse osmosis worked well in the metal finishing sector. Here, elements like nickel were entirely eliminated, while the removal efficiencies of other metal ions and organic materials were higher than 90%.

The effects of industrial growth: An important factor in a nation's economic growth is its industrial development. Since chemical fertilisers, pesticides, weedicides, and other industrial products are essential for raising productivity and advancing science and technology, industrial evolution is required for the revitalization of agriculture.

A severe lack of capital is the main problem facing the Indian economy. Affirmative and implicit wealth can help industry make more money, which can be used to spur expansion and improvement. Trade advances as a result of industrialization. In terms of global trade, export promotion and the creation of import substitute products are required to offset the balance of payments imbalance brought about by industrial expansion. When developing energy systems and policies, judgements about the effects that electricity production and use have on the environment must be taken into account. Every method of producing electricity, as well as every link in the fuel chain that has an impact both good and bad. The actual energy needs of the nation and societal values must be taken into account during the decision-making phase of the process.

Important effects on the environment: Hazardous material releases into the environment are likely the result of uncontrolled industrial effluent. According to (Upadhayay *et al.* 2017), wastewater produced by a variety of sectors has been linked to health problems such cancer, immune system problems, lung, and respiratory ailments. According to the State Inspectorate for Environment Protection (PIOS), over 60% of wastewater poses a real or prospective risk to the environment and public health. Risk assessments, including hazard identification, exposure assessment, and risk characterization, should be taken into consideration for more dependable and safe wastewater management. According, to (Tiffin C. *et al*. 2018) [58], industrial wastewater typically contains germs that cause cholera, typhoid fever, and other allergic reactions. These bacteria include Salmonella and *E. coli*.

Organic chemical-manufacturing industries: The chemical industry have the biggest environmental impact of all the industries. This industry typically releases wastewater that is highly concentrated in potentially hazardous organic and inorganic contaminants. It has been noted that the majority of the discharged effluents have non-biodegradable, carcinogenic, and mutagenic qualities. Chemical effluents are treated using the most widely used techniques, including dissolved air flotation, de-emulsification, gravity separation, skimming, coagulation, and flocculation.

Iron and steel industry: Wastewater from coke oven by-product plants is thought to be the most polluting in the iron and steel sector. Ammonia, cyanide, and phenol are among the hazardous substances in this effluent that are bad for the receiving water bodies. Untreated wastewater from the steel industry is known to have a number of negative effects, including toxicity to aquatic life, a decrease in dissolved oxygen (DO), and silting caused by suspended solids. Ammonia and phenol released into the wastewater raise the pH of the water, which causes the toxicity. When biodegradable organic materials are released into water bodies, the soil and bacteria consume the organic matter as a source of carbon, which lowers the water's DO level.

Food Industry: Because food industry waste water has a high Chemical Oxygen Demand (COD) and BOD level, it pollutes the environment. Since water is needed for the majority of plant operations, the food sector uses a lot more of it than other industries. The variation in total solids, suspended solids, and BOD/COD in the effluents of various companies was reported by (Noukeu NA *et al.* 2016) [59]. This is because different food products utilise different ingredients. Because the chocolate industry uses a lot of water, it is one of the food sectors that pollutes the most. Various techniques for treating effluent in the food industry are shown

Dairy Industry: Solid organic chemicals are generally present in high concentrations in the wastewater produced by the dairy industry. Substantial volumes of milk containing substantial amounts of milk ingredients like casein and inorganic salts are primarily handled by the dairy sector. The amount of milk processed and the kind of product made have a considerable impact on the effluent's quality. Presents characteristics of dairy effluent. The majority of the physicochemical techniques used in the dairy industry for wastewater treatment include chemical precipitation, coagulation/flocculation, membrane processes, etc. These techniques have an efficiency of up to 98%.

Mills That Extract Oil: One of the most popular products in homes is edible oil. These oils are produced in mills using a variety of processes, including pre-chilling, packaging, grinding, pressing, bleaching, deodorising, and oil extraction. The ETP unit and the bleaching process produce the majority of the effluent (Rajkumar K *et al*. 2010) [41]. The effluents go through initial treatment as well as secondary procedures such as biological and physicochemical (air flotation, coagulation, and flocculation).

The leather sector: The global leather industry is among the most rapidly expanding and most polluting sectors of the economy. The unfavourable environmental conditions are the result of the leather processing Pindustry. The processed leather is used to make a variety of goods, including carry bags, textiles, shoes, and much more. To do this, enormous amounts of raw materials are gathered and treated with chemicals to produce the finished product.

Pharmaceutical Sector: Since the pharmaceutical industry uses 99% of water to produce excipients, it is one of the primary businesses that heavily pollutes water bodies. The majority of the water discharged by this industry comes from areas used to manufacture drugs, which contain a variety of hazardous substances that are bad for both people and animals. The presence of constituents including BOD, COD, TSS, and TDS in the effluent is reduced by applying a variety of treatment techniques, including membrane flotation, reverse osmosis, flocculation, and coagulation (Azizi E *et al.* 2017) [3].

Agriculture Industry: The commercial agriculture sector uses a lot of water from many sources and produces a lot of waste water. According to (Levy GJ *et al.* 2011) [60], these wastewaters typically contain pollutants such as organic matter, inorganic matter (dissolved minerals), nutrients (nitrogen, phosphorus, and potassium), toxic compounds, and pathogens. Pesticides, BOD, COD, viruses, suspended solids, fertilisers, manure, and suspended solids will all be eliminated by the various filtration techniques used. The agricultural industry uses a variety of mechanical techniques for treating wastewater, including flotation, sedimentation, separation, flotation, and crystallisation; biological techniques, such as activated sludge in anaerobic conditions; and physicochemical techniques, such as electro-coagulation, coagulation and flocculation, and ozonation (Oron G *et al*. 2012) [34].

The pulp and paper industries: Pulp and paper have a significant influence on our daily lives. Massive amounts of biomass are produced by the pulp and paper sectors (Hubbe *et al.* 2016) [14]. Numerous processes are involved in the manufacturing of pulp and paper, including debarking, chipping, pulping, and bleaching.

Recirculating aquaculture systems that are integrated: As the productivity of marine fisheries has decreased over time, research into intensive aquaculture has increased in an effort to supply the world's need for marine protein. Closed aquaculture or RAS, Thus, in order to address some of the environmental problems related to the release of aquaculture wastewaters, as well as the lack of fresh water supplies and land, technologies have been devised. Researchers have outlined a number of the benefits of utilizing a recirculation system that have been covered in general.

Although the naturally occurring microbial community in the RAS was in charge of nitrogen remineralization, these RAS are nonetheless subject to organic loading during the production cycle. Shrimp survival will be threatened in the RAS when harvesting approaches because of a rise in water turbidity and ammonia and nitrite (NO_2) content. A nitrification process that uses microbiological activity to change NH_4 + to NO_2 - and then NO_3 - will absorb roughly 22% of the dissolved oxygen in RAS. In order to keep the concentration of NH_3 and NO_2 in RAS at a level that is safe for the life of cultivated prawns, this process is crucial. In recent years, RAS has drawn a lot of interest in the development of aquaculture; nevertheless, its high-water quality requirements, which are crucial to the survival of the cultivated species, make it difficult to implement. Other water management strategies must be taken into account and assessed as part of the RAS component in order for RAS to be successfully incorporated into the aquaculture business. These water management strategies will comprise membrane-based screening procedures (Bernhard *et al.*, 2008) [61], ozone technology, and further chemical and bio-filter-based disinfection procedures.

- The research' aquaculture water sample imitated fish aquaculture.
- There is insufficient information available on actual large-scale recirculating aquaculture systems, especially those that combine recirculating aquaculture with membrane bioreactors.
- The lack of clarity in the equipment specifications prevents the assessment of costs.
- The two systems' respective capacities for processing pond water have varying volumes, which will cause variations in the projected performance.

Table 1: An overview of the benefits of water recirculation systems for the aquaculture sector

Advantages	Explanation	Effect on the culture system
Wastewater with a low concentration is released	Aquaculture systems that use water recirculation can restore and enhance the quality of the water that is in the system. There won't be much or any effluent released.	Minimal chance of a disease breakout. It is possible to reduce the amount, of stressors in the aquaculture system to a safe level that will prevent disease outbreaks.
Biosecurity	It is possible to reduce the amount of dangerous biological agents released into the environment.	Disease transmission into the surrounding cultural system is carefully controlled.
Negligeable use of water	The least quantity of water is exchanged with the environment.	The surrounding water quality won't have as much of an impact on the culture system's production.
Geographical location requirements might be more lenient.	Access to fresh water can be readily obtained when the need for it is limited.	The culture system's geographical location will be more adaptable. It is possible to avoid completely destroying mangrove habitats to make room for aquaculture.

Application of water hyacinth for wastewater treatments: Water hyacinth's chemical makeup is composed of 95% water and 5% dry matter with high cellulose and hemicellulose contents. (Sindhu *et al*., 2017) [45]. The species known as water hyacinth is widespread in tropical and subtropical locations and is very temperature-dependent (Vymazal *et al.*, 2008) [51]. Nevertheless, because of the high salinity that inhibits water hyacinth growth, it is not seen in coastal areas (Rezania *et al*., 2015) [42]. Weed control techniques are challenging because water hyacinth seeds can survive below the water for up to 20 years under unfavourable conditions (such as low temperature and light intensity). Water hyacinth's chemical makeup is composed of 95% water and 5% dry matter with high cellulose and hemicellulose contents (Sindhu *et al*., 2017) [45]. The species known as water hyacinth is widespread in tropical and subtropical locations and is very temperature-dependent (Vymazal *et al.,* 2008) [51]. Nevertheless, because of the high salinity that inhibits water hyacinth growth, it is not seen in coastal areas (Rezania *et al*., 2015) [42]. Weed control techniques are challenging because water hyacinth seeds can survive below the water for up to 20 years under unfavourable conditions (such as low temperature and light intensity). Neither only are they neither economical or environmentally beneficial, but there has also been little progress made because it is still hard to completely remove all forms of water hyacinth from waterbodies (Mayo *et al*., 2017) [28]. It is still possible to stop the spread of water hyacinth by using such control methods, nevertheless. The best course of action is to use water hyacinth to improve society and the environment rather than trying to remove it (Rai *et al*., 2016) [40]. For example, water hyacinth is frequently utilised in the phytoremediation method to remove different types of contaminants from wastewater from homes and businesses.

Conclusion

The review's objective was to compile the most cutting-edge technologies and efficient control methods for dealing with instances of water pollution, with an emphasis on basin. Among the possible methods for controlling water pollution were discussed: overlay analysis in geographic information systems (GIS), cultural asset mapping, and relational values of water usage. A number of the most cutting-edge water pollution treatment methods now in use were also included in the assessment, including membrane technology, chemical precipitation, adsorption, ion exchanges, electrokinetic processes, and Phyto-remediation. Since there isn't yet a single technology that can completely or effectively handle all pollution episodes, several objective and multiple benefit technologies are needed to achieve water quality criteria. These days, there are various cutting-edge technologies that can be used to deal with contaminants in soil, water, or the air. However, doing so requires taking into account a number of elements. More importantly, it is essential to take preventative measures against pollution because cleaning up polluted areas and water bodies requires remedial efforts, which are typically more costly. The study suggests that in order to stop the practice of illegal mining operations in and around waterbodies and water courses, it is crucial to emphasise the need of intense public education and sensitization campaigns. To bring sanity to the artisanal small-scale mining industry, it is necessary to support University of Mines and Technology (UMaT) ASM projects like Sustainable Mining Awareness Day in partnership with the Ministry of Lands and Natural Resources and the Small-Scale Miners Association. Remedial measures like phytoremediation technology project, which involves planting specific tree species that can absorb pollutants like mercury from the environment and then be harvested, thereby removing the pollutants from the ecosystem, must also be adopted. Additionally, the application of AI has shown to be crucial due to its potential to improve decision-making, adaption, and mitigation. We suggest that more research be done to determine which particular tree species work best for phytoremediation because they have a strong affinity for absorbing and accumulating dangerous substances like mercury. It is evident that industrial wastewater effluent is clearly laden with harmful heavy metals, organic compounds, dyes, and other substances that cannot be effectively handled, making it a contaminant to the environment. The improper disposal of industrial wastewater results in ecological degradation, rendering the water unfit for human use on a regular basis. It is believed that wastewater discharged from sectors including textile, paper, oil and pulp, brewing, food and beverage, etc., offers a comprehensive understanding of industrial wastewater and the issues associated with its disposal.

We also recommend evaluating the species' growth and adaptability in various polluted environments with the assistance of artificial intelligence. With the use of AI, the research may result in the creation of novel strategies to address pollution issues in the mining sector and other industries, creating a cleaner, safer, and more sustainable environment for coming generations. Furthermore, the government should strengthen Ghana's ability to respond and immediately address the crippling impacts of illicit mining on water resources in cooperation with environmental agencies and business players.

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