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Research Article

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Comparative Analysis of Wastewater Treatment Using Microbial Technology and Nanotechnology

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Abstract
Huge resources are provided by the Indian government to acquire purified drinkable water for the general public for health concerns in this contemporary period of advanced technological implementation, with the goal of improving health and reducing disease epidemics. Many purifying businesses have used microbial technology to handle waste water, but current research using nanotechnology has sparked interest in creating even superior wastewater systems. This study compares the treatment of wastewater using microbial and nanotechnology, and the results show significant reductions in all physical and chemical parameters, demonstrating their efficacy. However, microbial technology outperforms nanotechnology treatment in terms of reducing chemical impurities.

Keywords: Microbial Technology, Wastewater Treatment, Nanotechnology, Chemical, Water parameters, Water Pollution

1. Introduction

In the present industrial world, wastewater treatment is an essential operation. Additionally, more than 97% of water is kept in saline (oceans) and only 3% in fresh water, with less than 1% of that amount being suitable for human use [1]. As the population grows throughout time, the government will need to supply more potable water for the general public. Wastewater is cleaned using chemical, physical, and biological techniques in order to safeguard the environment and general welfare. While the Romans built sewers to get rid of the rancid smell of spent water, the primary goal of modern wastewater treatment is to eliminate or reduce hazardous contaminants such nutrients, carbon, inorganic, and organic pollutants.

1.1 Sources of Fresh Water Pollution

Untreated sewage discharge, dumping, industrial effluent, and runoff from agricultural areas are the main causes of fresh water contamination. Freshwater bodies are negatively impacted by industrial development, urbanization, and the rising usage of synthetic chemical compounds.

It is commonly acknowledged that wealthy nations experience issues with chemical discharge into water sources, mostly groundwater, whereas underdeveloped nations deal with issues with agricultural runoff into water sources. Water borne diseases are caused by contaminated water, such as pollutants in drinking water, which can be avoided by acting even at the household level.

- **Pesticides:** Pesticides like DDT are found in run-off from farms, backyards, and golf courses.

- **Sewage:** Untreated city sewage is a significant contributor to the pollution of ground and surface waters in developing nations.

- **Nutrients:** Manure from livestock operations, fertilizer runoff from agricultural activities, and industrial effluents all contribute to eutrophication in lakes and rivers, which then spreads to coastal areas. The main source of nitrates is the fertilizer that is applied to the fields. Ground water becomes contaminated with nitrates as a result of excessive fertilizer use.

- **Chemicals:** Both naturally occurring and artificially added chemicals in water have the potential to seriously harm human health [2].

1.2 Waste Water Related Problems

Disease: Water-borne illnesses spread through faces and are contagious. The faces of diseased people contain pathogens, which are disease-causing organisms like viruses, bacteria, protozoa, and parasitic worms.

a) Pesticides are found in waste water; the organophosphates and carbonates they contain influence and harm the neurological system and can lead to cancer.
b) Lead is unhealthy because it builds up in the body and harms the central nervous system. The most vulnerable groups are kids and pregnant women.
b) Fluoride: Too much fluoride can harm the spinal cord and cause teeth to yellow.
d) Arsenic: Skin cancer, liver damage, and nervous system damage can all result from drinking water contaminated with arsenic.
Other heavy metals: Heavy metals harm the kidney and nervous system.

Depending on the contaminant that is present in the water body, exposure to polluted water can induce diarrhoea, skin irritation, respiratory issues, and other diseases. Untreated water serves as a habitat for a variety of parasites and insects, including the mosquito, which is a major cause of disease, particularly in tropical areas. Undoubtedly the most contagious disease and the one that harms people's health the most is malaria [2] **[Figures 1 and 2].**

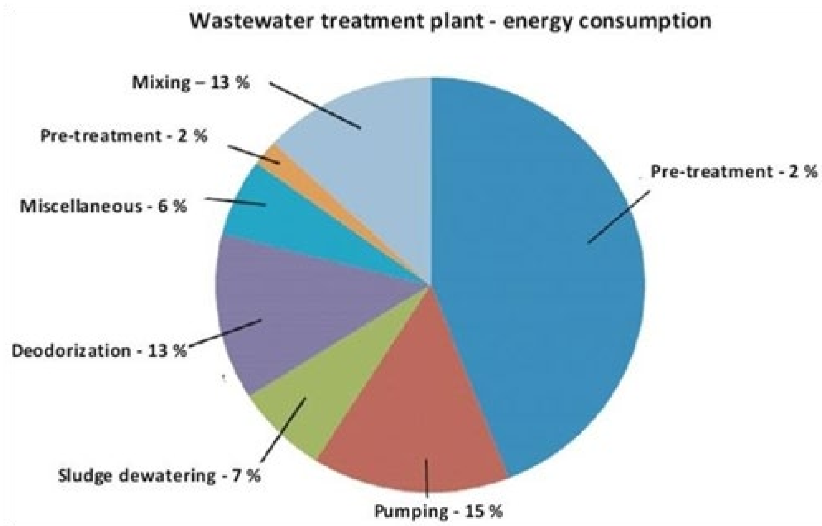

Figure 1: Energy Consumption Required for Wastewater Treatment

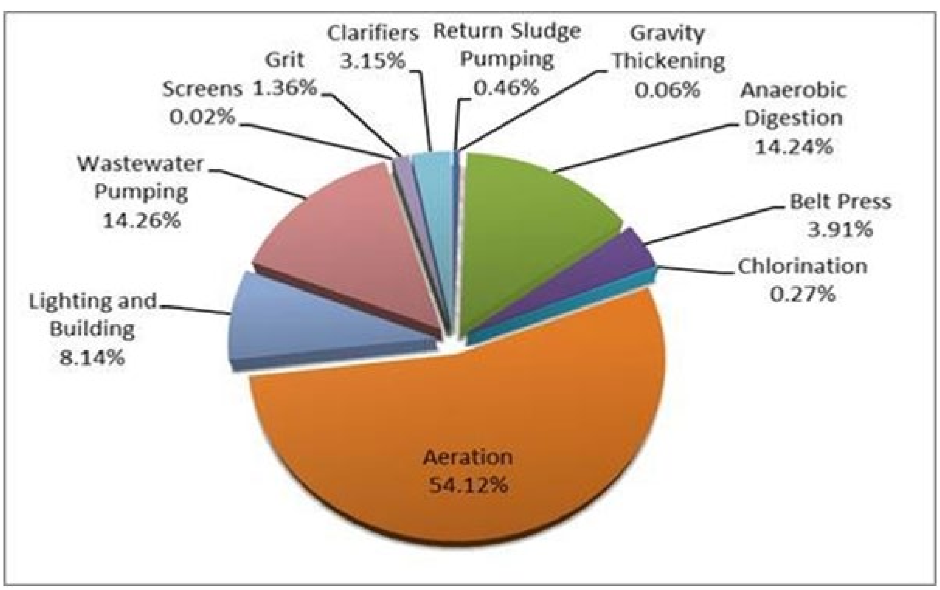

Figure 2: Different Ways of Wastewater Treatment Processes

1.3 Treatment Process
To ensure good water and sanitation quality, the treatment procedure must be separated into various treatment steps.

Stage One: Screening
The initial step in the treatment of wastewater is screening. Large objects that could obstruct or harm equipment, such as diapers, nappies, sanitary products, cotton buds, face wipes, and even broken bottles, bottle caps, plastics, and rags, are removed during screening. Additionally, grit that is washed into the sewer is removed using specialized equipment.

Stage Two: Primary Treatment

In this, organic solid matter (or human waste) is separated from the wastewater. To do this, wastewater is placed in enormous settlement tanks, allowing the solids to settle to the bottom of the tank. The 'sludge'-like solids that have settled are known as such. Large scrapers at the bottom of these circular tanks continuously scrape the tank's floor, forcing the sludge toward the centre, where it is pumped away for additional treatment. After that, the remaining water is transferred to the secondary treatment [3].

Stage Three: Secondary Treatment

At this point, the water is placed in huge rectangular tanks. They are referred to as aeration lanes. To help microorganisms break down the minute fragments of sludge that escaped the sludge scrapping process, air is introduced into the water [4].

Stage Four: Final Treatment

The 'nearly' cleaned wastewater is then sent into a settlement tank. Here, additional sludge is created at the tank's bottom due to the bacterial action's tendency to settle. The sludge is once more scraped and gathered for treatment. At this point, the water is essentially devoid of pollutants and hazardous compounds. In order to eliminate any extra particles, the water is allowed to pass over a wall and through a bed of sand.

The water treatment process has the potential to yield a number of additional advantages in addition to producing clean, reusable water. It has the ability to lower a nation's trash generation, harvest methane for energy, and create natural fertilizer from the waste that is gathered during the process [5].

1.4 Benefits of Waste Water Treatment

Waste that is typically dumped into the environment is minimized by wastewater treatment, increasing the health of the environment. By doing this, the government lowers the hazards to public health brought on by environmental pollution as well as the water loss brought on by water pollution. Wastewater treatment also lowers a nation's financial outlay for environmental restoration initiatives needed to combat pollution.

2. Energy Production

Since the sludge produced during the treatment process has a significant amount of biodegradable material, it too must be treated. In specialized, completely contained digesters heated to 35°C where these anaerobic microorganisms may survive without oxygen, it is treated with anaerobic bacteria. Methane, which is extracted from the gas created by this anaerobic process and burned to produce power, is present in high concentrations.

If there is an excess of energy produced, it could be sent into a nation's national grid. This energy can be utilized to run wastewater treatment plants, making them self-sustaining. This lessens a nation's dependency on non-renewable energy sources like fossil fuels, lowering its carbon footprint and its cost of producing energy. Al-Samra wastewater treatment facilities in Jordan are an example of how this method is employed in the Middle East. Government representatives claim that by burning the methane created during the treatment process, the facility generates 40% of the energy it needs.

2.1 Fertilizer Production

The remaining biodegradable matter is dried in "drying lagoons" and transformed into organic fertilizer. The resulting organic fertilizer is subsequently applied in agriculture to raise crop yields. This decreases the use of chemical fertilizers that pollute the surrounding marine and surface ecosystems [2].

2.2 Objectives

1) Gather wastewater from a highly polluted area of the water and assess the purity characteristics.
2) Determining the wastewater samples' water purity characteristics after microbial technology treatment.
3) Determining the wastewater sample samples' water purity characteristics after nanotechnology treatment.
4) Justified comparison of the two wastewater treatment methods.

3. Review and Literature

3.1 Background

In the present industrial world, wastewater treatment is an essential operation. Additionally, more than 97% of water is kept in saline (oceans), and only 3% in fresh water, yet less than 1% of this water is usable for human use. As the population grows, the government will need to provide more potable water for the general public. Wastewater is cleaned using chemical, physical, and biological techniques in order to safeguard the environment and general welfare.

Wastewater treatment is a modern practice. Unlike the ancient Romans, who built sewers to get rid of the smelly waste water, today's sewage systems are built primarily to reduce or remove hazardous pollutants like nutrients, carbon, and inorganic and organic elements By using unfiltered wastewater established the most advantageous method for treating sewage and wastewater [6,7]. This method emits the fewest contaminants into the environment, which also has an impact on the lives of the general people.

Wastewater is defined as water that has been released into the environment and has wastes added to it from a variety of uses, including industrial, commercial, residential, and other uses. There are two sources that release wastewater into the environment. First, sewage/community wastewater is the kind that has been discharged from domestic locations like institutions, homes, and business enterprises and is organic due to the consistency of carbon composites like vegetables, human waste, paper, etc.

The second is wastewater that has been generated by industrial processes, which is also composed of organic materials [7].

3.2 Review of Background Bibliography

The initial attempt at wastewater treatment involved discharging the pollutants into rivers, which served as the sources of the majority of water supply. The public became aware of this issue in

1871 when the future King Edward VII contracted typhoid fever while vacationing at a mansion in Yorkshire [4]. As a result of his illness and the discovery that the cause was poor drainage, efforts were made right once to upgrade the sanitary infrastructure. By the 19th century, many towns had come to the realization that they needed to lessen the amount of water pollution they released into the environment. After Louis Pasteur and his associates demonstrated that bacteria found in sewers may spread infectious diseases (e.g. 1), sewage systems were conceived of and built. Sewer systems began to expand in the early 1990s, but as cities grew, less places remained for dumping and filtration [8]. In addition, the population boom caused a substantial rise in wastewater production [9]. Due to the fact that earlier designs were unable to meet modern societal demands, treatment facilities have changed in size. Overall, (NIRAJ S. and TOPARE) introduced three key goals for the treatment of water.

i The Evacuation of postponed particles and floatable materials.

ii. The treatment of organic elements in the wastewater BOD removal.

iii. The removal of micro-organics which may be the cause of dangerous diseases.

Only with more organized, systematic approaches have these goals been carried over into early pollutant removal and reduction operations. The science of water treatment has been infused with more aims, even though the older treatment goals are still viable due to the invention and development of new treatment methods [10].

3.3 Domestic Wastewater Characteristics

The primary driver behind creating effective wastewater treatment plans and installing sewers in cities is domestic wastewater. Domestic pollutants might have physical, chemical, or industrial properties. Physical pollutants include things like colour, temperature, and weight.

The suspended materials that cannot dissolve or have settled in the waste water are the cause of the wastewater's recent grey colour, which gradually turns to black as time passes. Additionally, the sediments add to the wastewater's weight, which has been calculated at 1,000,000 grams per cubic meter.

Because of the heating pipes in the buildings and home activities, sewage water is warmer than regular water. It is believed that domestic wastewater has a temperature between 10°C and 20°C. It is more difficult to define the properties of chemical wastewater than it is to describe those of physical wastewater.

Wastewater contains a wide variety of chemical components, making it challenging to measure them precisely. To make measurements simpler, the subject matter experts divided the chemicals found in wastewater into broad groups of substances. For instance, polyphosphates, orthophosphates, and organic phosphate are all grouped together under the heading "Total Phosphorus (as P)" [11].

3.4 Wastewater Treatment Procedure Unit Processes of Treatment

Numerous wastes and pollutants, including nutrients, inorganic salts, pathogens, coarse particles, etc., are present in wastewater and are extremely hazardous to both humans and the environment. Various procedures have been revealed to remove these contaminants. Sewage/wastewater treatment involves a number of distinct procedures and unit operations, all of which have as their main objective the reduction of water pollution from the point at which the process begins to the point of disposal or reuse [12].

Advanced cleansing relies heavily on chemical unit operations. It was noted that chemical unit processes are the ones used when physical and biological processes are active. These processes produce reactions in wastewater components. Precipitation, coagulation, neutralization and stabilization, ion exchange, oxidation, and advanced oxidation are just a few of the numerous chemical processes that can be added to sewage water throughout the purification process.

Physical unit activities, such as flocculation, floatation, mixing, filtration, screening, and gas transfer, are some treatment techniques that remove waste by employing physical forces. Biological unit processes are the steps taken by bacteria that naturally develop in a biological reactor to break down grease/oil, suspended particles, organic materials, nitrogen, and phosphorus. The fundamental objective of this treatment is to reduce the biological elements in wastewater, because bacteria in sewers devour carbon-based material [13].

3.5 Types of Waste Water Treatment

The processes and operations which were mentioned are being used in different stages of treatment; Preliminary, Primary, Secondary and Advanced wastewater treatment which are perusing different objectives in the treatment process.

Preliminary Wastewater Treatment: The objective is to remove the large materials like coarse solids which are being frequently seen in wastewater. Furthermore, it separates the floating materials which are being carried by water flow. Preliminary treatment procedures usually contain grit removal, coarse screening and comminution of large objects. In addition, this treatment helps in removing the greases and oils. This process decreases the wastewaters BOD, by approximately 15 to 30% and the devices which are being used during this treatment are Grit chamber and Comminutor.

3.5.1 Comminutor: This device consists of a screen to prevent the large materials from accessing further into the following treatment processes and some cutters are also installed after the screen to chop the solids which had made it through the screen.

3.5.2 Grit Chamber: its objective is to remove the oils and semi-liquid elements. There are two kinds of Grit chamber; Aerated and Vortex.

3.5.3 Primary Wastewater Treatment: The objective is to remove solid components of wastewater by sedimentation, these components can be organic elements such as, phosphorus, nitrogen, and metals connected to solid components. On the other hand, colloidal and dissolved elements will remain and not be affected. The waste from primary sedimentation units is known as primary effluent and the wastes which have been produced by this process is called Primary effluent. The devices which are being used in primary treatment are Sedimentation tank and clarifiers and Anaerobic Digester [14].

3.5.4 Sedimentation Tank and Clarifiers: "Up flow clarifiers and Rector clarifiers are two types of sedimentation tanks, perform very well if both the raw water is characteristics and the hydraulic loading rates are constant" Anaerobic.

3.5.5 Digester: Most of the primary waste is being treated biologically in this system. Anaerobic digester is being used in huge plants.

3.5.6 Secondary Wastewater Treatment: This treatment is used after the primary treatment which completes the cleansing process through reducing the amounts of remaining organic elements and solid particles; in addition, biodegradable removal and colloidal. Organic matter used aerobic biological bacteria in secondary treatment processes. Bacteria will decompose the fine organic matter, in some biological units to produce a clear effluent while aerobic bacteria oxidize the organic matter in some treatment units which called as treatment reactors and may consist of oxidation ponds, aerated lagoons, aeration tanks, rotating biological contactors and trickling filters [4].

Tertiary/ advanced wastewater treatment and wastewater reclamation: The objective is to remove the specific wastewater constitutes which cannot be removed by secondary treatment including toxic substances, organic elements and solid particles. Tertiary removal uses the stream of a river for recycling or industrial heat reduction and groundwater renewal [5].

3.5.7 Role of Microorganisms in Waste Water Treatment

Microorganisms play a key role in bioremediation process and have been proven as an efficient, low cost and environmentally friendly alternative to physicochemical methods. Several microbial species including fungi, bacteria and algae have been studied for their capacity to degrade and decolorize toxic chemical pollutants present in various industrial wastewater including distilleries. Free or immobilized cells have been studied widely for bioremediation of distillery wastewater. Immobilizing microorganism on inert support material including alginate, polyacrylamide, agar, polystyrene, and polyurethane is more advantageous compared to that of free-cell. Some of the advantages include compact physical structure of carrier pellets, high biomass retention, reusability of culture and easier separation process. The potential of microorganisms in distillery wastewater treatment is highly dependent on the type of chemical composition of wastewater, nutrient, pH, temperature, oxygen and inoculum size [15].

3.5.8 Bacterial Treatment

A wide variety of bacterial cultures as *Pseudomonas aeruginosa, Pseudomonas putida, Lactobacillus plantarum, Bacillus circulans, Bacillus megaterium, Bacillus firmus, Bacillus thuringiensis, Bacillus cereus, Lactobacillus hilgardii, Lactobacillus coryniformis, Xanthomonas Fragaria* have been reported for their activity in degradation and decolorization of pollutants from distillery effluents [16].

A wide variety of aerobic or anaerobic bacterial strains have been involved in bioremediation of distillery wastewater. However, a large number of bacterial species including *Bacillus sp*., *Pseudomonas sp., Alcaligenes sp.* and acetogenic bacteria operates effectively under aerobic conditions. Tiwari et al. [16]. isolated thermotolerant bacterial culture comprised of *Bacillus subtilis, Bacillus cereus and Pseudomonas aeruginosa* from soil contaminated with distillery wastewater. *Among which Bacillus subtilis* showed maximum decolorization 85% at 45°C in the presence of little amount of carbon (0.1%, w/v) and nitrogen sources (0.1%, w/v) within a very short incubation period 24 hrs. *Bacillus cereus and Pseudomonas sp*. showed 73 and 69% decolorization, respectively under optimum conditions. Bacillus subtilis showed best thermotolerance ability and could tolerate 35-50°C without affecting exponential growth phase. According to reports from different investigations the genus Bacillus showed the highest bioremediation efficiency compared to other bacterial cultures. Various strains of *Bacillus sp*. showed an average decolorization 75-81%, COD 80-85% and BOD 85-95% removal efficiency whereas other species as *Alcaligenes sp*., Pseudomonas sp. and acetogenic bacteria removed colour by about 50-78%, COD 62-76% and BOD 70-82% under optimum conditions. Aerobic bacterial strains are very effective in bioremediating distillery effluents under aerobic conditions. However, those bacterial strains are not economical due to high energy consumption for aeration thus; it was very difficult to apply those bacterial strains on an industrial scale.

Considering this problem, it is important to isolate bacterial strains that can degrade distillery wastewater under anaerobic condition. Anaerobic bacterial strains are advantageous than that of aerobic strains due to low energy consumption hence, minimizes cost of wastewater treatment. Ohmomo et al.. reported the first bacterial strain *Lactobacillus hilgardii* W-NS capable of decolorizing molasses melanoidins under anaerobic condition. This bacterial strain decolorized about 28% of molasses melanoidin under optimum condition. Another facultative anaerobic bacterial culture L-2 belonging to *Lactobacillus* showed similar decolorization of 31% for 12.5% (v/v) diluted digested spent wash in 7 days of incubation. Along with decolorization this bacterial culture also removed 56.2% COD. Nakajima et al. observed decolorization yield of 35.5% using bacterial strain MD-32 within 20 days of cultivation under both thermophilic and anaerobic conditions. The COD and colour removal efficiency of anaerobic bacterial strains is lower than that of aerobic bacteria. Hence, it is important to isolate bacterial strains capable of degrading and decolorizing toxic chemical pollutants under anaerobic condition [17].

3.5.9 Fungal Treatment

In recent years, several fungal strains have been investigated for their ability to degrade and decolorize distillery wastewater. Table 2 presents some of the fungal cultures involved in bioremediation of distillery wastewater. One of the most studied fungi having high molasses wastewater bioremediation activity belongs to the genera of *Aspergillus*. Miranda et al. studied colour elimination from anaerobic-aerobically treated beet molasses spent wash using Aspergillus Niger. The fungal culture showed COD and colour removal yield of about 65 and 75%, respectively when supplemented with 10 g/L sucrose, 1.8 g/L NH_4NO_3, 1 g/L KH_2PO_4 and 0.5 g/L $MgSO_4.7H_2O$ with an initial pH of 5. In the culture with the optimal nutrient concentration 83% of the total colour removed was eliminated biologically and 17% by adsorption on the mycelium used mycelia of a thermophilic strain *Aspergillus fumigatus* G-2-6 for batch and continuous decolorization of melanoidin solution [18]. This strain decolorized about 75 and 70% of a molasses melanoidin solution under batch and continuous culture, respectively when the strain was cultivated on a glycerol-peptone medium at 45°C within 3 days. At the same time, about 51% of the chemical oxygen demand and 56% of the total organic carbon in the initial solution were removed. Later on they observed similar decolorization yield of 75% using autoclaved *mycelium of Aspergillus* Oryza No. Y-2-32 when it was cultivated at 35°C for 4 days on glycerol peptone medium with shaking. The main melanoidin decolorization activity of this strain was due to the adsorption of melanoidin to mycelia. This fungal strain adsorbed lower weight fractions of melanoidin and degree of adsorption was influenced by the kind of sugars used for cultivation. White- rot fungi are among most widely exploited microorganisms because of their capacity in bioremediation of toxic compounds. They produce various forms of complex and non-specific intracellular and extracellular enzymatic system including laccases, manganese peroxidases, lignin peroxidase, and sugar oxidase involved in the degradation of various toxic pollutants. The most widely studied white-rot fungal species in bioremediation of distillery wastewater are Phanerochaete spp, *Flavodon spp., Coriolus* spp. and *Trametes sp*. Among white-rot fungi the highest melanoidin decolorization in a range of 80-82% have been reported for Coriolus spp. No. 20, *Coriolus versicolor* Ps4a, *Trametes versicolor* and *Trametes hirsuta* under optimum conditions. Along with decolorization and COD removal, white rot-fungi are also effective in removing phenolic compounds from distillery wastewater. It has been reported that *Trametes pubescens* MB 89 and *Phanerochaete chrysospotium* can remove 80 and 63% total phenolic compounds from wastewater. In another report *Flavodon flavus* removed benzo(a)pyrene a polycyclic aromatic hydrocarbon (PAHs) 68% from molasses spent wash within 5 days [19].

3.5.10 Algal Treatment

Microalgae are unicellular microorganisms that are known for their capacity in bio adsorption and biodegradation of toxic chemical pollutants as phenols, heavy metals, pesticides, polycyclic aromatic hydrocarbons (PAHs), xenobiotics and melanoidins from wastewater. Utilizing microalgae for bioremediation purpose is advantageous compared to that of bacterial and fungal systems in many ways. The first advantage is that, microalgae have a great potential in utilizing contaminants as ammonium, nitrate and phosphate as a nutrient hence minimizes the amount of externally added nutrient in case of fungi and bacteria. Secondly fungi and bacteria require optimum condition for growth and bioremediation activity whereas microalgae can grow rapidly and adapt harsh conditions. Thirdly microalgae produce valuable products as ethanol, methane, livestock feed, or it can also be used as organic fertilizer due to its high N:P ratio. Hence, utilizing microalgae for bioremediation purpose is advantageous compared to fungal and bacterial system. Various species of microalgae as *Chlorella vulgaris, Oscillatoria boryana, Chlorella pyrenoidosa, Chlorella sorokiniana, Coenochloris pyrenoidosa, Nostoc muscorum, Neochloris oleoabundans, Phormidium valderianum, Chlorella zofingiensis, and Chlorella ellipsoidea* have been used in bioremediation of wastewater. The green microalgae belonged to the genera of Chlorella have been studied most widely due to its capacity of bioremediating toxic chemicals pollutants. Valderrama et al. carried out research to develop a procedure for treatment of recalcitrant wastewater from ethanol and citric acid production using first the microalga *Chlorella vulgaris* followed by the macrophyte *Lemna minuscula*. In the first stage of treatment, *Chlorella vulgaris* resulted in a reduction of ammonium ion 71.6%, phosphorus 28% and chemical oxygen demand 61% from 10% diluted wastewater within 4 days of treatment. Travieso et al. evaluated the performance of a laboratory-scale microalgae pond for secondary treatment of distillery wastewater previously digested in an anaerobic fixed bed reactor using Chlorella vulgaris SR/2. *Chlorella vulgaris* SR/2 removed volatile suspended solids (VSS) 78.8%, total solids (TS) 60.6%, total suspended solids (TSS) 53.4%, chemical oxygen demand (COD) 83.2% and biochemical oxygen demand (BOD) 88.0% from the effluent. More recently, Solovchenko et al. investigated phytoremediation of alcohol distillery wastewater with a novel *Chlorella sorokiniana* strain isolated from White Sea. This algal strain showed maximum reduction in chemical oxygen demand (COD) 92.5%, nitrate 95%, phosphate 77% and sulfate 35% within four days. Another marine *cyanobacterium Oscillatoria boryana* decolorized pure melanoidin pigment (0.1%) and crude pigment in the distillery effluent (5%) by about 75% and 60%, respectively, within 30 days of treatment [20].

3.5.11 Mixed Culture Treatment

Several researchers studied the efficiency of mixed culture microorganisms for degradation and decolorization of distillery wastewater. The mixed microbial cultures exhibited increase in mineralization of effluents over that showed by individual cultures. This might be due to the enhanced effect of coordinated metabolic interactions present in mixed community observed enhanced growth, enzyme production and melanoidin degradation by mixed bacterial culture compared to axenic bacterial culture [21]. In that report a mixed consortium comprised of *Bacillus licheniformis*, *Bacillus sp*. and Alcaligenes sp. showed melanoidin decolorization of about 73.79 and 69.83% for synthetic and natural melanoidins whereas axenic cultures decolorized 65.88, 62.56 and 66.10% synthetic and 52.69, 48.92 and 59.64% natural melanoidins, respectively. In another report, a mixed bacterial culture comprised of *Bacillus thuringiensis, Bacillus brevis and Bacillus sp*. exhibited two-to four-fold increase in melanoidin decolorization over that showed by any individual *Bacillus* isolate. Pant and Adholeya developed a novel fungal consortium comprised of *Penicillium pinophilum, Alternaria gaisen, Aspergillus flavus, Fusarium verticillioides, Aspergillus Niger and Pleurotus florida* for decolorization of distillery effluent using agricultural residues as a growth substrate. The fungal consortium was run on a bioreactor with undiluted distillery effluent for 40 days. In the first 14 days, 61.5% colour and 65.4% COD removal was achieved.

EM technology is a technique in which the waste water is treated by effective microbes which can be recycled for the irrigation purpose [22]. The technology of effective microorganisms was developed during the 1970's at the University of Ryukyus, Okinawa, Japan. Studies have shown that EM may have a number of applications, including agriculture, livestock, gardening & landscaping, composting, bioremediation, cleaning septic tanks, algal control & household uses. The practical application was developed by Professor Teuro Higa. He has devoted much of his scientific career to isolating & selecting different microbes for beneficial effects on soils & plants. He has found microbes that can coexist in mixed cultures & are physiologically compatible with one another. When these cultures are introduced into the natural environment, their individual beneficial effects are greatly magnified in a synergistic fashion [23]. A microbial inoculant containing many kinds of naturally occurring beneficial microbes called 'Effective Microorganisms' has been used widely in nature and organic farming. EM detoxifies contaminated water and is ideal for biological balance. EM converts a degraded ecosystem to one that is productive and contains useful microorganisms [24]. New technologies are being produced to assist in the treatment and disposal of sewage sludge, conforming to strict environmental regulations. One of these new technologies is Nanotechnology. The term nanotechnology was coined by science university professor Norio Taniguchi in 1974. Nanotechnology deals with the object on the order of a nanometre in size. Nanotechnology is used for the treatment of surface water, ground water and waste water contaminated by toxic metal ions, organic and inorganic solutes and microorganism. Due to their unique activity toward recalcitrant contaminants many nonmaterial are under active research and development for use in the treatment of water. Hence in present investigation an attempt has been made to remodify the Yamuna waste water by non-synthesized and Silver Nitrate ($AgNO_3$) synthesized bacterial isolates.

4. Materials and Methods

4.1 Required Materials

Sample of Sewage Water: Taken from the Kuakhai downstream.

- **Distilled Water:** Distillation is the process of boiling water and then condensing the steam into a clean container. The result is water from which contaminants, such as dissolved salts and colloidal particles, have been eliminated by one or more distillation processes.

- **HCL:** Hydrochloric acid, which is hydrogen chloride in an aqueous solution. HCL, also known as muriatic acid, is a potent corrosive and irritating acid that is frequently employed in industry and laboratories. It is typically found in stomach juice in a diluted form.

- **NaoH:** Usually found as lumps, sticks, chips, or pellets, NaOH is a white, deliquescent, water soluble solid that produces heat when it is dissolved in water. It is primarily employed as a laboratory reagent and soap manufacturer, as well as in the production of other chemicals, rayon, and film.
Buffer Capsule pH 4 and pH 7: To create a solution of pH 4.0 and pH 7, dissolve the contents of one capsule and dilute it with up to 100 millilitres of purified water. This is done in order to calibrate pH.

- **Hexamethylenetetramine:** The heterocyclic chemical compound hexamethylenetetramine, sometimes known as methenamine, has the formula $(CH2)6N4$. This crystalline white substance dissolves readily in polar organic solvents such as water. It is helpful in the production of various chemicals, such as rubber additives, plastics, and medications. Hexamethylene tetraamine solution: To make hexamethylene tetraamine solution, dissolve 10 grams of hexamethylene tetraamine in 100 millilitres of distilled water.

- **Hydrazine Sulphate:** Hydrazine Sulphate is a salt that is made by sulfuric acid and hydrazine. It is a white salt that dissolves in water. Sulfuric acid is used to make it by treating an aqueous solution of hydrazine. It has a number of laboratories uses.

- **Potassium Chromate Indicator:** Because potassium chromate becomes red when there is an excess of silver ions present, it is also utilized as an indicator in precipitation titrations with silver nitrate and sodium chloride.
solution for potassium chromate indicator: Mix some distilled water with 50g of potassium chromate to dissolve it. Silver nitrate should be added until a red precipitate form. After letting it sit for 12 hours, strain and dilute with 1 litre of distilled water.

- **Standard Silver Nitrate Titrant:** dilute 2.395g of silver nitrate in 1 litre of distilled water (0.0141M).

- **Standard Sodium Chloride Solution:** Use purified water to dissolve 0.824g of sodium chloride (dried at 140°C) and dilute to 1 litre.

- **Sulfuric Acid:** Sulfuric acid has the chemical formula H_2SO_4 and a molecular weight of 98.079 g/mol. It is a very strong and corrosive mineral acid. It is a colourless to slightly yellow viscous liquid with an ethereal, strong smell that dissolves in water at all concentrations.

- **Phenolphthalein Indicator:** An acid-base indicator, phenolphthalein is colourless in acidic solutions but turns pink to crimson in alkaline solutions.

• **A Combination of Indicator Solutions (Bromocresol Green and Methyl Red):** Add 0.02g of methyl red and 0.01g of bromocresol green to 100ml of 95% ethyl or isopropyl alcohol and dissolve.

• **Patton and Reader's Indicator Solution:** The indicator is Patton and Reeder's Indicator (PR). Additionally, a compound involving this blue dye and calcium ions changes their colour from blue to pink or red.

• **EDTA Solution:** ethylene-diamine-tetra acetic acid is known by this acronym. It is utilized in numerous buffers because it chelates divalent cations. Compared to magnesium ions, its cousin EGTA is more affinitions for calcium ions.

• **Manganese Sulphate:** The inorganic substance with the formula $MnSO4.H_2O$ is commonly referred to as manganese sulphate. This delicate, pale pink solid is an important manganese (II) salt for commerce.

• **Potassium Hydroxide:** Also referred to as caustic potash, potassium hydroxide is an inorganic chemical having the formula KOH. This white solid is a classic strong base, along with potassium hydroxide. It has a wide range of industrial uses.

• **Potassium Iodide:** This substance can be taken as a food supplement, medicine, or chemical. As a medicine, it is used to treat hyperthyroidism, guard the thyroid gland when using specific radiopharmaceuticals, and handle radiation crises.

• **Sodium Azide:** The inorganic substance with the formula NaN3 is called sodium azide. This colourless salt is what many automotive airbag systems use to produce gas. It is employed in the process of making more azide compounds. It is an ionic material that is extremely acutely poisonous and highly soluble in water.

• **Sodium Thiosulfate:** which is often spelled sodium thiosulphate, is a chemical and drug. It is used as a medicine to treat pityriasis versicolor and cyanide poisoning. It's an inanimate substance. The solid is a crystalline efflorescent material that readily dissolves in water.

• **Potassium Chloride:** Made up of both potassium and chloride, potassium chloride is a metal halide salt. It looks like a white or colourless vitreous crystal and has no smell. The substance has a flavour similar to salt and dissolves easily in water. KCl is utilized as a fertilizer, in science, medicine, food processing, and as the third drug in the "three drug cocktail" used in fatal injection executions to induce cardiac arrest. It is found in nature as the mineral sylvite and as sylvinite when combined with sodium chloride.

4.2 Methodology

1. Collection of Waste Water Sample

Around 4 litres wastewater sample in sterilized BOD bottles was collected from Kuakhai downstream, Bhubaneswar.

2. Determination of the pH Value of the Sample

The pH meter was washed with distilled water and dried by tissue paper then the 4-buffer solution was taken in a beaker for calibration. Then again, the pH meter was washed with distilled water and dried properly by tissue paper for calibration by pH 7 buffer solution. After that pH reading of waste water samples were taken. pH of the waste water sample.

3. Determination of the Turbidity

Distilled water was taken in a small beaker and transferred to the cuvette and placed inside the turbidimeter then set the meter on zero. Turbidimeter was calibrated by the solution which was prepared by mixing 5ml of hexamethylenetetramine solution and 5ml of hydrazine sulphate solution after standing at 25°C to 28°C and dilute to 100 ml with distilled water and mixed well. After that turbidity of the sample was taken.

4. Determination of the Conductivity

The conductivity meter was switch on before 30 mints of calibration. The conductivity meter was calibrated by 0.1 N potassium chloride solution. After that the electrode was rinse by distilled water and wiped with a tissue paper. Then conductivity of the sample was measured by deep the electrode in the sample beaker.

5. Determination of Alkalinity

20 ml of solution was taken in a 100 ml beaker. 2 to 3 drops of mixed indicator were added which was prepared by dissolve 0.02 g methyl red and 0.01g of bromocresol green in 100ml distilled water. Then the mixed solution was titrated against standard Sulphur acid until the light pink colour was observed.

6. Determination of Calcium

50 ml of sample was taken in a beaker then to maintain the pH between 12 to 13 add approximately 2.0 ml of sodium hydroxide solution. Then 1gm mixture of Patton reader reagent and sodium sulphate or potassium sulphate was added to the ample. then titrate against standard EDTA solution until the colour change occur.

7. Determination of the Chloride

100 ml of sample was taken in a beaker and 1ml of hydrogen peroxide was mixed in the sample and stirred for 1 mint. Then adjust the pH between 7 to 10. and potassium chromate indicator was added to the solution and then titrate against the standard sodium chloride solution.

8. Determination of TS (Total Solid)

The clean evaporating disc was heated for 1 hour at 180°C in oven. Then it was cooled by placed it inside the desiccator until it was ready for use. After cooling, the blank weight of the evaporating disc was taken then 100 ml of sample was taken in the disc and the disc was placed on the evaporator. The sample was evaporated within 2 to 3 hours. The disc was placed in the oven for some time then placed it inside the desiccator and finally the final weigh of the sample was taken.

9. Determination of TS (Total Dissolved Solid)
100 ml of sample was taken and filtered after filtration the rest part was transferred to a evaporating disc and then the same procedure was followed like TS test.

10. Determination of Total Suspended Solid (TSS)
Total suspended solid = Total Solid - Total dissolved solid

11. Determination of DO (Dissolved Oxygen)
300ml of sample was taken in a glass stoppered BOD bottle from the field and any kind of bubbling was avoided. 2ml of manganese sulphate was added by inserting the pipette just below the surface of the liquid. After that in the same manner the alkali-iodide-azide reagent was added. A brownish-orange cloud precipitate was appearing because the presence of oxygen. Sufficient time was allowed to settled and react completely with oxygen. Then 2 ml of concentrated sulphuric acid was added to the sample.it was kept for 8 hours then it was titrated against sodium thiosulphate by using starch indicator.

12. Determination of Bod
Biological oxygen demand = Initial dissolved oxygen - Final dissolved oxygen

13. Microbial Wastewater Treatment
Nutrient broth was prepared then autoclaved it for sterilization after that the sample was added to the broth and incubated for 24 hours, then *E. coli* culture was added to the beaker under aseptic condition. Again, it was incubated for 24 hours for the complete growth of microbial culture (*E. coli, Bacillus subtilis, lactobacillus*) then all the parameters were tested.

14. Nanotechnology Based Wastewater Treatment
Nutrient broth was prepared then autoclaved it for sterilization after that the sample was added to the broth and incubated for a period of 7 days in darkness at room temperature along with 4 Mm silver nitrate in it and then all the parameters was tested.

5. Results and Discussion
5.1 Collection of Waste Water Sample
The untreated waste water was collected from Kuakhai downstream was slightly yellowish. **[Figure:3]**

Figure 3: Kuakhai Waste Water Sample

5.2 Determination pH Value of the Sample
• Microbial Wastewater Treatment

The complete growth of microbial culture (*E. coli, Bacillus subtilis, lactobacillus*) was obtained with turbidness then all the purity parameters was recorded.

• Nanotechnology Based Wastewater Treatment

The silver nanoparticle obtained culture was obtained with slight coloration change and then all the purity parameters was recorded.

• Determination pH Value of the Treated Sample

The pH of 50 ml wastewater at room temperature was found to be 8.2.

• Determination pH Value of the Untreated Sample **[Table 1]**

Bacteria	pH after Microbial treated	pH after Nano treated
E.Coli	7.1	7.3
B.Subtilis	8.1	8.4
Lactobacilus	7.5	7.9

Table 1: pH Value of the Treated Sample

5.3 Determination of the Turbidity
• Determination Turbidity of the Untreated Sample

The turbidity of 50 ml waste water at room temperature was found to be 2.8 ntu.

• Determination turbidity of the treated Sample [Table 2]

Bacteria	Turbidity after Microbial treated	Turbidity Nano treated
E.Coli	5.1ntu	7 .3 ntu
B.Subtilis	5.6 ntu	7.7ntu
Lactobacilus	5.3ntu	7.3ntu

Table 2: Turbidity of the Treated Sample

5.4 Determination of the Conductivity

• Determination Conductivity of the Untreated Sample

The conductivity of 50 ml waste water at room temperature was found to be 112.88µmho.

• Determination Conductivity of the Treated Sample [Table 3]

Bacteria	Conductivity after Microbial treated	Conductivity Nano treated
E.Coli	94.6µmho.	99.6µmho.
B.Subtilis	94.3µmho.	99.5µmho.
Lactobacilus	94.2µmho.	99.3µmho.

Table 3: Conductivity of the Treated Sample

5.5 Determination of Alkalinity

• Determination Alkalinity of Untreated Sample

The alkalinity of waste water at room temperature was found to be 45mg/lt

• Determination Alkalinity of Treated Sample [Table 4]

Bacteria	Alkalinity after Microbial treated	Alkalinity after Nano treated
E.Coli	20.2mg/lt	38.3mg/lt
B.Subtilis	20.4mg/lt	38.5mg/lt
Lactobacilus	20.5mg/lt	38.7mg/lt

Table 4: Alkalinity of the Treated Sample

5.6 Determination of Calcium

• Determination Calcium of Untreated Sample.

The calcium of waste water sample was found to be 18mg/lt.

• Determination Calcium of Treated Sample [Table 5]

Bacteria	Calcium after Microbial treated	Calcium after Nano treated
E.Coli	15.7 mg/lt	18mg/lt
B.Subtilis	15.4mg/lt	17.9mg/lt
Lactobacilus	15.5mg/lt	17.7mg/lt

Table 5: Calcium of Treated Sample

5.7 Determination of Chloride

• Chloride Amount Present in Untreated Sample

The chloride of waste water sample was found to be 14mg/lt.

• Chloride Amount Present in Treated Sample [Table 6]

Bacteria	Calcium after Microbial treated	Calcium after Nano treated
E.Coli	15.7 mg/lt	18mg/lt
B.Subtilis	15.4mg/lt	17.9mg/lt
Lactobacilus	15.5mg/lt	17.7mg/lt

Table 6: Chloride Present in Treated Sample

5.8 Determination of Chloride

• Chloride Amount Present in Untreated Sample

The chloride of waste water sample was found to be 14mg/lt.

• Chloride Amount Present in Treated Sample [Table 6]

Bacteria	Total solid after Microbial treated	Total solid after Nano treated
E.Coli	20.43mg/lt	3.89mg/lt
B.Subtilis	16.7mg/lt	1.82mg/lt
Lactobacilus	16.44mg/lt	03.12mg/lt

Table 7: TS Present in Treated Sample

5.9 Determination of Total Dissolved Solid

• TDS of Untreated Sample

The total dissolved solid of waste water sample was found to be 25.5 mg/lt.

• TDS of Treated Sample [Table 8]

Bacteria	Total dissolved solid after Microbial treated	Total dissolved solid after Nano treated
E.Coli	13.5mg/l	4.5mg/l
B.Subtilis	15.mg/l	3.6mg/l
Lactobacilus	18.3mg/l	5.9mg/l

Table 8: TDS in Treated Sample

5.10 Determination of Total Suspended Solid

• TSS of Untreated Sample

The total suspended solid of waste water sample was found to be 5 mg/l.

• TSS of Treated Sample [Table 9]

Bacteria	Total suspended solid after Microbial treated	Total suspended solid after Nano treated
E.Coli	13.5mg/l	4.5mg/l
B.Subtilis	15.4mg/l	3.6mg/l
Lactobacilus	18.3mg/l	5.9mg/l

Table 9: TSS of Treated Sample

5.11 Determination of Dissolved Oxygen

• Dissolved Oxygen of Untreated Sample.

The dissolved solid of waste water sample was found to be initially-7.9mg/l.

• Dissolved Oxygen of Treated Sample [Table 10]

Bacteria	Total dissolved oxygen after treatment	Total dissolved oxygen after Nano treated
E.Coli	5.7mg/l	6.1 mg/l
B.Subtilis	5.3mg/l	6.3mg/l
Lactobacilus	5.1mg/l	6.5 mg/l

Table 10: Dissolved Oxygen Treated Sample

5.12 Determination of Dissolved Solid

• Dissolved Solid of Untreated Water

The dissolved solid of waste water sample was found to be after 5 days that is final DO-4.6mg/l.

• Dissolved Solid of Treated Water [Table 11]

Bacteria	Total dissolved oxygen after treatment	Total dissolved oxygen after Nano treated
E.Coli	3.1mg/l	4.4 mg/l
B.Subtilis	3.0mg/l	4.2mg/l
Lactobacilus	2.9mg/l	3.8 mg/l

Table 11: Dissolved Solid of Treated Water

5.13 Determination of Biological Oxygen Demand

• BOD of Untreated Sample

The biological oxygen demand of waste water was found to be 3.3mg/l.

• BOD of Untreated Sample [Table 12]

Bacteria	Total dissolved oxygen after treatment	Total dissolved oxygen after Nano treated
E.Coli	3.1mg/l	4.4 mg/l
B.Subtilis	3.0mg/l	4.2mg/l
Lactobacilus	2.9mg/l	3.8 mg/l

Table :12 BOD of Treated Sample

6. Conclusion

The major issue of total mortality rate is from water borne diseases which shows concern for achieving better solutions to water problems. According to WHO, at least 30000 people die every day because of polluted water supply. High levels of pollutants mainly organic matter cause an increase in BOD (Biological Oxygen Demand), TSS (Total Suspended solids) etc. Usage of microbes has been implemented for obtaining purified water by industries effluent treatment but new day technology on nanomaterial input has put an interest to check its vitality in water treatment which is evident from this research work.

The findings of this research investigation show the both microbial cultures and nanoparticle incorporated cultures have the potential to eradicate the pollutants but with slight differences. Microbial Cultures gave reduction in chemical pollutants whereas nanotechnology based showed biological contaminates reduction.

This present study was an attempt to obtain a remedial solution for wastewater using non-synthesised and synthesized silver bacterial isolates where it is proved by results microbial technology is a better, stable and effective wastewater treatment which detoxifies contaminated water and is ideal for biological balance.

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