Analysis of Industrial Wastewater Treatment Processes

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ABSTRACT: The paper investigates some analysis upon industrial wastewater treatment procedures, with aerobic, anaerobic, or a combination of both approaches being utilised in these studies. The paper attempts to precisely explore the academics' as well as researchers' inspirations, instrumentation, and findings. The handling of chemical industrial wastewater from a structure as well as the building chemical plant besides a rubber shoe workshop is looked at. The wastewater from the many plants is discharged into the municipal sewage system. The wastewater released from the structure as well as the building chemical plant is found to be heavily polluted with organic compounds, according to the findings. BOD (biochemical oxygen demand) and COD (Chemical oxygen demand) averaged149.9mgO₂/l and2911.9, respectively. Phenol concentrations as high as 0.29 milli gram/litter were found. With ferric chloride and lime chemically treated was effective, and the effluent had a characteristic that was within Egyptian permissible limits. Domestic wastewater is combined with industrial wastewater at the other factory to minimise the load i.e., organic. After blending, the BOD and COD values were 2614.9 and 5238.9 mgO₂/litter, respectively. 0.49 milli gram/litter is the average phenol concentration. As a result, the chemical industrial wastewater's characteristics decide which treatment scheme to use. Engineering construction of each treatment system based on laboratory findings.

KEYWORDS: aerobic reactor, aerobic and anaerobic, chemical industrial wastewater, organic, pulp and paper, wastewater treatment plant

1. INTRODUCTION

For environmental effect, the chemical industry was important. This industry's wastewaters are typically strong as well as encompass poisonous contaminants. Inorganic besides organic matter are commonly found in variable concentration in chemical industrial wastes. It comprises a low suspended solid content, a bright hue and matter with a high biological oxygen demand, poisonous materials, bases and acids. Numerous chemical ingredients are poisonous, mutagenic, carcinogenic, or only partially biodegradable. Many treatment unit activities suffer from the use of petroleum hydrocarbons, emulsifiers, and surfactants, which are utilized in the chemical industry. The finest technique for cleaning heavily polluted and hazardous industrial wastewater was to treat it at the cause. In terms of environmental effects, the chemical industry is important

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This industry's wastewaters are normally high in organic and inorganic contaminants, and they can also contain radioactive pollutants. Organic and inorganic matter in differing amounts are normal in chemical industrial wastewaters. Many chemical industry compounds are poisonous, mutagenic, carcinogenic, or almost non-biodegradable. Pre-treatment is needed to generate an equivalent effluent since these wastes vary in general features from domestic sewage. The practise of wastewater treatment in the chemical industry is characterised by high variability, rigorous effluent permits, besides extreme operating conditions [2]. The art of wastewater treatment in the chemical industry is characterised by high uncertainty, strict effluent permits, and extreme operational conditions.

1. Aerobic and Anaerobic Wastewater Treatment

The term "aerobic" refers to the existence of oxygen (air), although "anaerobic" refers to the lack of air (oxygen). As a result, aerobic treatment processes take place in the presence of air and employ microorganisms (also known as aerobes) that assimilate organic impurities by converting them to carbon dioxide, water, and biomass using molecular/free oxygen. Anaerobic treatment procedures, on the other hand, are carried out by microorganisms (also known as anaerobes) that do not require air (molecular/free oxygen) to assimilate organic impurities in the absence of air (and thus molecular/free oxygen). Methane and carbon dioxide gas, as well as biomass, are the end products of organic assimilation in anaerobic therapy.

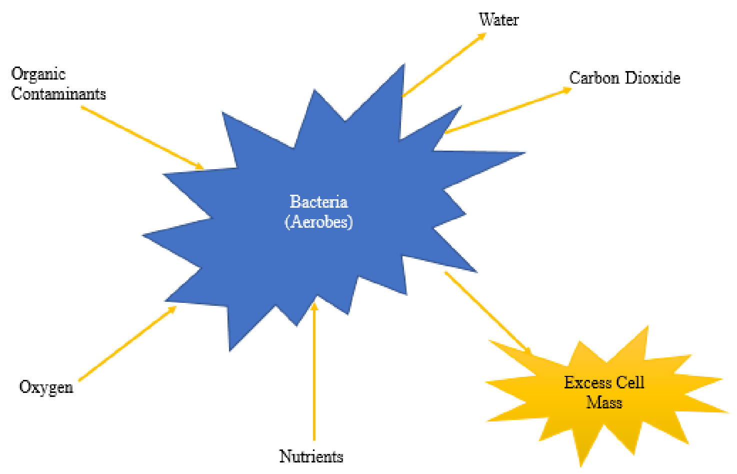

Fig. 1: In Bacteria (Aerobic Process)

The triggered sludge method was used in batch laboratory experiments. Plexiglas laboratory columns with a capacity of two litres were used. Enabled sludge from a domestic sewage treatment facility was applied to the wastewater. Aeration was shut off daily to allow until a significant volume of adapted sludge was formed. Several tests were carried out to determine the effect of the aeration cycle upon the activated sludge. A pre-treated wastewater was applied to a separate column with a set volume of sludge (2.9–3.9 g/l) moved to it. The researchers looked at jail times spanning from an hour to complete one day. After 1 hour of settlement, the treated wastewater was characterised [3].

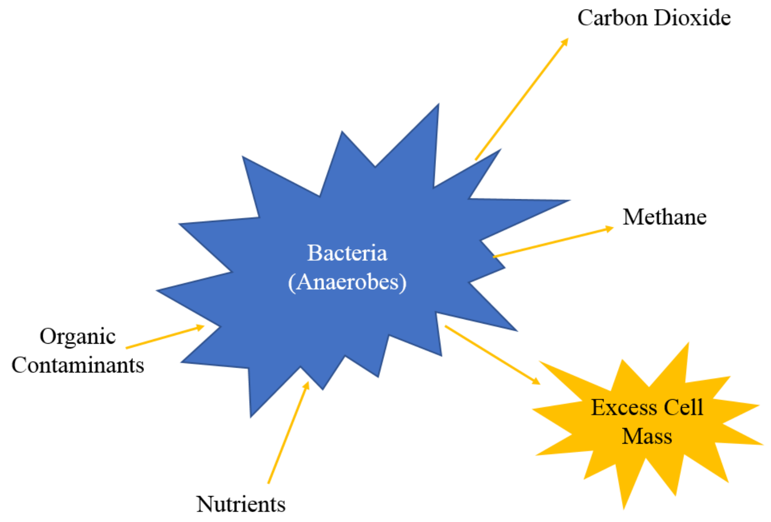

Fig. 2: In Bacteria (Anaerobic Process)

Aerobic treatment processes, such as the traditional activated sludge (CAS) process, are commonly used to treat low-strength wastewater (less than 999.9 mg COD/L), such as municipal wastewater. Fig. 1 shows the aerobic unit, which consisted of a bio-film reactor accompanied by a sedimentation tank. Due to the high aeration requirements, the CAS process is energy intensive, and it also creates a significant amount of sludge (approximately 0.39 gm dry weight/gm COD detached) that must be treated then disposed of. As an outcome, the cost of running besides maintaining a CAS system is very high. Anaerobic processes (Fig. 2) for domestic wastewater treatment was a potentially more cost-effective option, especially in sub-tropical and tropical areas. In the last few decades, anaerobic wastewater treatment has become more popular. These methods are important because they have positive impacts, such as removing greater organic loading, producing less sludge and removing more pathogens, producing methane gas, and using less energy.

2. LITERATURE REVIEW

Mahdi *et al.* performed a combined anaerobic-aerobic system for textile wastewater treatment in 2007. Textile manufacture uses a significant amount of water during the production process. The water is largely used in the textile industry's dyeing and finishing operations. The textile industry wastewater is the most polluting of all industrial sectors, both in terms of volume produced and effluent composition. In their research, a continuous operation of a combined anaerobic-aerobic reactor was used to treat wastewater from textiles. Cosmo ball is utilized as a microorganism development medium in an anaerobic reactor. In the nitrification and denitrification processes, the effects of pH, dissolved oxygen, and organic changes were analysed. The results showed a removal effectiveness of over 84.619 percent ammonia nitrogen and about 98.89 percent volatile suspended solid (VSS) [4].

Gapariková *et al.* investigated how to develop an optimised system based on a mixture of anaerobic and aerobic technologies. Following operating practise, it can be controlled usefully for the organic waste removal besides suspended solids, as well as nutrient removal under ideal conditions. When compared to a small WWTP that operated on aerobic standards, energy consumption dropped by around 24.9% to 39.9%. The AS-ANA comb's operation reported a 39.9 percent reduction in real sludge output. The WWTP's frequent start–up is not causing any significant issues due to proper service. The AS-ANA comb's procedure uncovered several concerns, resulting in a decline in care quality. In certain ways, this is due to the accumulation of products that shouldn't go into WWTPs (grease, gasoline, solvents, washing agents) [5].

Florante *et al.* did a preliminary study which was conducted upon the efficiency of removal of organic besides nitrogen. The researchers used a synthetic wastewater with high nitrogen level. The aim of the analysis is to compare the performance of the anaerobic as well as the aerobic reactors in separating COD besides nitrogen from wastewater rich in nutrient. Moreover, it shows the results of start-up tests performed upon artificial wastewater with separate reactor configurations: aerobic and anaerobic was tracked by calculating the concentration of biomass characterized by mixture of liquor volatile solid, which was fed continuously to the two reactors (MLVS) [6]. Florante *et al.* published a preliminary study upon the efficacy of organic as well as the nitrogen removal in a lab-scale system utilizing anaerobic and aerobic reactor. The effects of dissolved oxygen (DO) and pH on the nitrification process were found to be minor; Only 2.9% of pH changes were accomplished for each ten percent reduction in nitrogen [6].

Bashaar *et al.* has described laboratory size were used to classify and treat wastewater from Jordanian mills, respectively. The lower commonly stated in the literature for P: N: C ratios of 0.9:4.9: 99.9 for aerobic treatment and 249.9:4.9:0.9 for anaerobic treatment in the literature. This is due to the wastewaters' poor biomass yield coefficient as well as comparatively low removal efficiencies. It is discovered that anaerobic treatment performed upon olive mill wastewater with a P: N: COD ratio of around 1.69:4.9: 899.9 was capable of eliminating more than 79.9% of COD. The biomass yield was 0.059 kilogram VSS per kilogram of COD degraded, according to the data [7].

Hu *et al*. suggested a notion for choosing the best treatment procedure for chemical industrial wastewater founded upon biodegradability as well as the pollutants' molecular size. Roughly biological oxidation systems, like lagoons, activated sludge, rotating biological contactors (RBC), or trickling filters, is utilized to treat chemical industrial wastewater. Coagulation accompanied by sedimentation or flotation can be used to treat pollutants with molecular sizes greater than 9,999-19,999. Fluctuations in the drainage flow can also be a bothersome cause. The efficiency of selected AS-ANA comb WWTPs can be positively measured. The majority of the WWTPs tested were effective in removing organic contamination without the need for specialist service, which is one of the most critical criteria for small wastewater treatment plants. Even in a temperate climate, the findings of WWTP activity demonstrated the feasibility of an optimised anaerobic-aerobic method for urban wastewater treatment [8].

Bury *et al.*; 2002 used dynamic simulation to maintain as well as the control of treatment plant in the chemical industry by the virtue of the variation in rate of flow besides strength. The primary goal of this research was to assess the application of alternative wastewater treatment technologies in the chemical industry. Preliminary findings found that after a dozen days, an aerobic reactor with a hydraulic retention period (HRT) of five hours achieved a 98 percent reduction in COD, while an anaerobic reactor with the identical hydraulic retention period achieved a 34 percent reduction in COD after two weeks. A COD: N:P ratio of around 169.9:4.9:1.49 was capable to accomplish more than 74.9 percent COD elimination for prolonged aeration aerobic treatment of pulp and paper mill wastewater. The biomass about 0.309-kilogram of COD degraded. Nutrients were not applied to any of these wastewaters [9].

Hu *et al.* suggested a method for determining the best disposal procedure for chemical industrial wastewater founded upon biodegradability as well as the contaminants' molecular size. Waste minimization is the first and most critical step in the chemical industry's production process to prevent waste formation. The chemical oxygen demand (COD) was measured to monitor the removal of organic pollutants until a steady state condition was achieved. COD and nitrogen studies, were also carried out utilizing various feed concentrations on nitrogen elimination. Founded upon experiential biomass yield coefficient as well as the removal efficiency, a basic formula is applied to measure nutrient requirements [8].

3. METHODOLOGY

3.1 Design:

The efficiency of the system was investigated using a laboratory scale combined anaerobic-aerobic reactor.

3.1.1 Anaerobic reactor

The transparent PVC anaerobic reactor has a 29.9 cm diameter, 29.9 cm height, and a total working volume of 17.9 litre with supporting particles to keep micro-organism in the system immobilised, as well as an over-all 1.9-liters sludge which is active from a palm oil mill are gathered as well as nourished in reactors from Hulu Langat, Malaysia. The support material had a total surface area of 192.559m^2. Chemical treatment with lime and ferric chloride was successful, and the effluent had a characteristic that was within Egyptian permissible limits.

3.1.2 Aerobic reactor

The transparent PVC aerobic reactor has a diameter of 19.9 cm, a height of 47.9 cm, and a total working volume of 8.9 litres. The aerobic reactor received a total of 1 litre of sewage sludge from the Indah Water Konsortium (IWK). Because the aerobic reactor's main function was polishing only, acclimatisation of the aerobic sludge was not as important as it was for the anaerobic reactor. A fine bubble diffuser supplied the air, and a flow metre kept the flow at 5.9 mg/l/min. They came to the conclusion that the combined anaerobic-aerobic system could handle high-strength textile wastewater. Ammonia nitrogen, BOD, COD, and VSS removal rates were 84.619 percent, 63.639 percent, 59.9 percent, and 98.89 percent, respectively. COD, BOD, as well as the Ammonia nitrogen concentrations in the final effluent were discovered to be 108.749 milli gram/litter, 13.169 milli gram/litter, and 1.109 milli gram/litter, respectively.

pH as well as the DO is found to possess only minor effects upon the nitrification procedure, with only 2.9% of pH changes occurring for each 9.9% reduction in nitrogen. The denitrification rate was 0.059 mg NO_3/VSS when the COD/NO3 ratio was 27.9 percent, and this rate would reduce as the dissolved oxygen concentration rises. Fayza *et al.* published a study on chemical industrial wastewater treatment in 2004. The factory of building and construction chemicals, as well as the factory of plastic shoes, were analysed. The wastewater from the two plants is discharged into the public sewer system. The wastewater discharged from construction chemicals factory as well as the building were found to be heavily polluted with organic compounds. COD and BOD averaged 2911.9 and 149.9 mgO_2/l, respectively. Phenol concentrations as high as 0.29 mg/l were found.

3.2 Sample:

Aerobic biological therapy was carried out utilizing a rotating biological contactor as well as an activated sludge. The geometry of the instrumentation is shown below (Fig. 3):

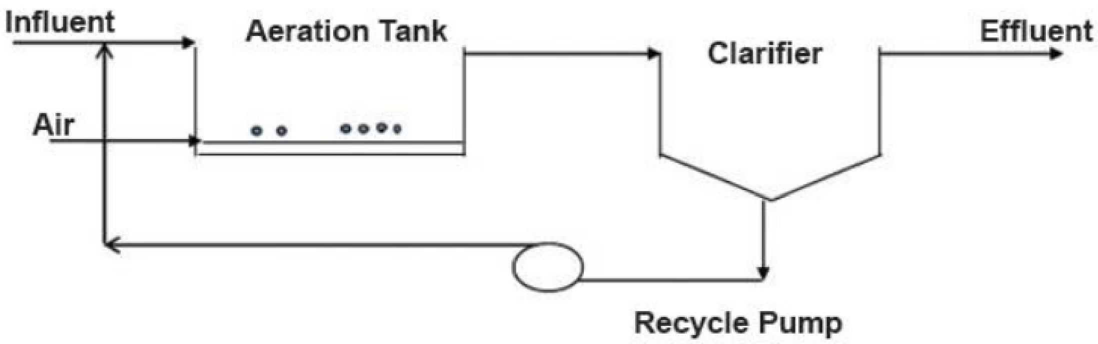

Fig. 3: System for Activated Sludge Processing in the Past

According to their findings, chemical industrial wastewater characteristics, determine the appropriate treatment system. The use of domestic sewage in the factory to dilute chemical industrial contaminants efficiently reduces the concentration and toxicity of the contaminants, increasing the effectiveness of biological treatment. The researchers used a simulated sewer with high nitrogen levels. Preliminary findings revealed that after 10.9 days, an aerobic reactor with an HRT (hydraulic retention period) of five hours achieved a 97.9 percent reduction in COD, while an anaerobic reactor with the equivalent hydraulic retention period (HRT) achieved a 33.9 percent reduction in COD after 2 weeks.

It also shows the results of start-up tests performed upon simulated wastewater with double different reactor configurations: the anaerobic as well as the aerobic. Starting experiment was conducted utilizing a 3.9-liter flask anaerobic reactor as well as a 4.9-liter acrylic aerobic reactor with activated sludge as an inoculum source controlled the concentration of biomass signified by mixture of liquor volatile solid, which was fed constantly to the two reactors (MLVS) was measured to track the reduction of organic pollutants until a steady state condition was attained.

3.3 Instrument:

Aerobic and anaerobic reactors were used in the experiments. An air pump was used in the aerobic zone of 4.9 litters. A continuous anaerobic reactor, on the other hand, a 3.9-liter Erlenmeyer flask with stir bar as well as a magnetic stirrer to allow for constant stirring inside the reactor. The reactor utilized in the learning are revealed in the picture as: Batch reactors with various concentrations of wastewater were made up of five 0.9-liter Imhoff cones reinforced by an iron ring as well as an iron stand, as shown in the diagram below. For aeration, air pumps were used in each reactor. The biomass yield was 0.059 kg VSS per kg of COD degraded, according to the findings. The biomass 0.309-kilogram VSS of COD degraded.

The following conclusions were drawn from the experimental results: Aerobic processes take longer to aerate and create a lot of sludge, but they are effective at removing ammonium nitrogen. Anaerobic treatment processes typically have advantage like the production of useful biogas as well as the higher organic loading rates; however, they also have disadvantages such as a comparatively greater effluent concentration and the inability to remove ammonium nitrogen. At the same HRT, the aerobic reactor reduced COD by 97.9 percent, while the anaerobic reactor only reduced COD by 33.9 percent. Nutrients were not added to any of these wastewaters. Founded upon experimental biomass yield coefficient as well as the removal efficiency, is implemented to determine nutrient needs.

3.4 Data Collection:

The active volume of the research was 1.9 L. The mixture of OMW was prepared as well as the preserved at 29.9±1.9°C utilizing a magnetic stirrer/hotplate for anaerobic treatment. Mixing and heating were switched off after the mixing period was finished, and the reactor is left idle for the two hours duration so that anaerobic sludge gets settled. Following this, the determined volume of supernatant is detached from the reactor besides subjected to a series of tests in accordance with. Under anaerobic conditions, the COD of the reactor is retained near about at 15,999.9 milli gram/litter by diluting after the start-up phase. Sludge wastage was carried out in order to maintain the VSS (volatile suspended solids) concentration in the reactor possibly, near to 11,999.9 milli gram/litter.

Three days are chosen as the hydraulic retention time. The pH of the reactor is 6.9 utilising sodium bicarbonate as needed. Dissolved oxygen concentrations in paper and pulp mill wastewater are retained from 1.9 to 3.9 mg/l for aerobic treatment, extended aeration was chosen as the treatment mode. The average time for hydraulic retention was 1 day. The reactor was fed three times a day with 669.9 ml each time. The MLVSS concentration (mixed liquor volatile suspended solids) was preserved at around 2499.9 milli gram/liter. He also found that the nitrogen and phosphorous concentrations in Jordanian olive mill wastewater as well as the paper and pulp mill wastewater are adequate, and that no additional nutrients are required.

The COD: N:P ratio used for aerobic and anaerobic treatment of industrial wastewater should be calculated from a formula that takes into account the removal efficiency and observed yield for the wastewater in question (40.9/EYobs:4.9:0.9). Finally, for testing, these WWTPs were built with the help of Slovak Technical University, ASIO-SK s.r.o. Byta, and ASIO s.r.o. Brno. They operate on the concept of anaerobic pre-treatment and aerobic post-treatment. Plants for wastewater treatment are designed for 4.9-598.9 PE. The results match the directive water discharge from small wastewater treatment plants in the Slovak Republic when operated under the right conditions.

3.5 Data Analysis:

The study presented here is split into two parts: laboratory research in reactors AN-I and AN-II, and research with assessment of a real-world WWTP, AS-ANA comb. The experiment used two pilot-scale reactors with aerobic post-treatment. Reactor AN-I (shown in Fig. 1, which consists of a main settling tank, an anaerobic baffled system, an aerobic component, and a secondary settling tank), seeded with anaerobic sludge (~200 l, SS concentration 17.9-21.9 g/l). Reactor AN-II was constructed in the same way as AN-I, but it was started up without being inoculated. Both experimental plants were installed (39,999 PE) municipal wastewater treatment plant in Bratislava. From September 1999 to August 2001, pilot scale experiments with both reactors were conducted. The underlying wastewater parameters of the influent and effluent (COD, BOD5, pH, SS, NH_4-N, NO_3-N, NO_2-N) were tracked utilizing Standard Methods.

In the second section, seven genuine WWTPs, one for 9 PE, three for 19 PE, two for 199 PE, and one for 249 PE, were selected for assessment. The samples were taken from WWTPs in Slovakia's north western region. The samples were taken five times from the effluent of the WWTP between August and October 2003, and they were all grab samples. The samples were analysed for COD, BOD5, pH, SS, NH_4-N, NO_3-N, and PO_4-P using Standard Methods. According to the findings of their research, an integrated system was created by combining the aerobic as well as the anaerobic technologies. Subsequent operational experience, it can be settled that appropriately controlled bi-stage technology was efficient for the elimination of suspended solids besides organic pollution, as well as nutrient removal under ideal conditions. When compared to a small WWTP that operated on aerobic principles, energy consumption dropped by about 24.9% to 39.9%.

The AS-ANA comb's operation confirmed a 39.9 percent reduction in special sludge production. The WWTP's repeated start–up is not causing any major issues due to proper operation. The AS-ANA comb's operation revealed certain issues, resulting in a reduction in treatment effectiveness. In many situations, this is due to the accumulation of stuff that shouldn't go into WWTPs (grease, gasoline, solvents, cleaning agents). Fluctuations in the wastewater flow can also be a bothersome factor. The performance of selected AS-ANA comb WWTPs can be positively assessed. The majority of the WWTPs tested were effective at removing organic pollutants without the need for professional operation, which is one of the most critical criteria for small wastewater treatment plants even in a temperate climate.

RESULTS AND DISCUSSION

The workshop generates 10.9–14.9m^3/d of wastewater. The typical values of BOD (149.9 mgO2/l) and COD (2911.9 mgO_2/l), (Table 1). In the average, the BOD/COD ratio was 5.9%. The presence of phenol was observed in the sample, with a concentration of 0.29 milli gram/litter. The grease and oil concentrations between 148.9 and 599.9 milli gram/litre, with a typical of 370.9 milli gram/litre. The gross suspended solids concentration averaged 199.9 mg/l. The wastewater at the end of the conduit was treated chemically with activated sludge. The phosphorous as well as the nitrogen concentrations in the wastewater were found to be deficient.

Table 1: End-of-Pipe Wastewater Has Many Characteristics (Construction Chemicals Factory and Building)

Variables	Max.	Minimum	Mean	Units	Egyptian decree
Grease & Oil	599.9	148.9	371	mg/l	100
Phenols	0.3	0.06	0.1	mg/l	0.05
Organic Nitrogen	25	9	19	mgN_2/l	100
Phosphorous	30	0.8	9	mgP/l	25
Total suspended solids	519	157	199.9	mg/l	800
Biological Oxygen Demand	570	210	149.9	mgO_2/l	600
Chemical Oxygen Demand	3924	1870	2911.9	mgO_2/l	1100
pH	9.5	6.1	7.5	mg/l	6-9.5

The concentration of nitrogen and phosphorous salts was modified to satisfy the needs. The characteristics of treated effluent do not meet the acceptable limit. The biodegradability at a very low level, as specified by the ratio of BOD to COD is 5.9% only, which is to blame for this result. On a bench scale, aluminium sulphate is carried out first to determine the best coagulant, optimal dosage, and pH, and then a continuous method was used.

4. CONCLUSION

For many parts of the world, anaerobic systems have proven to be an effective therapy technology. WSP's conventional system will undoubtedly compete more and more with UASB systems in the future. Aerobic structures, such as ponds, trickling filters, or activated sludge plants, are also required for post-treatment. The more plants there are, the is integrate processes. anaerobic digesters are used complex sludges. However, it hasn't been widely used in the past. Anaerobic reactors, on the other hand, were thought during fluctuations, costly a longer start-up period. This belief stemmed from a lack of understanding anaerobic treatment has now been substantially reduced thanks to technological advancements. The use of anaerobic processes steadily enlarged in the previous thirty years, thanks to the work of Young and McCarty in 1969. Due to substantial benefits over aerobic treatment.

The bench scale was critical previously moving on to the continuous system. The use of domestic sewage in the factory to dilute chemical industrial wastewaters efficiently reduces the accumulation and toxicity of toxins while also saving money because are used to supply nutrient in biological treatment systems. Spinning biological contactors are an easy to use and maintain device that yields outstanding performance.

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