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Assessment of Sago Wastewater Treatment Process in an Aerobic Bio-Reactor with the Support of Chemisorbent

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Abstract**:** ***The Performance of an Aerobic Bio-Reactor (ABR) for the behavior of synthetic sago processing wastewater was investigated. The system with 13.3 liters of working volume was accomplished by attached as well as suspended growth process. The experimental analysis was carried out with the influent Chemical Oxygen Demand of 3920 mg/l, 4360 mg/l and 4640 mg/l at Hydraulic Retention Times (HRT) of 11, 14, 17, 21, 28, 42, 84 and 141 hours. During the experiment, pH plays an important role and the Dissolved Oxygen was maintained within the permissible limit continuously. In an ABR, the maximum COD removal efficiency was attained 91.20% with an Organic Loading Rate (OLR) of 1.518 kg COD/m3. To achieve the goal of reusing the wastewater, again the treated effluent was analyzed by the technology of adsorption process using zinc oxide nano powder as a Chemisorbent and the maximum COD removal efficiency of 100% was observed with 0.75 g of dosage content at the pH of 6 at the contact time of 180 minutes.***

Keywords**:** ***Adsorption, Nanotechnology, Organic Loading Rate, and Wastewater Treatment.***

I. INTRODUCTION

Water is our most valuable resource, and because we are more concerned about future water supplies, we are required to use new, changed technology to protect these water bodies from contamination. Industrial effluents that include large amounts of solids, COD, and have a high unstable pH are difficult to treat. As a result, sewage is frequently discharged into nearby bodies of water without even a basic treatment. In order to treat wastewater, a number of traditional procedures have been used. However, they are not efficient in their effectiveness. The biggest challenge of sago sector is getting rid of effluent that doesn't match the standards. Due to constraints in present water and wastewater treatment technologies, it is no longer viable to provide a sufficient amount of high-quality water that fulfils human and environmental demands [18], [15], [16], [7],[13], [17], [21]. As the effluent from the sago business restrains significant amounts of whole materials, proper treatment before discharge is crucial [8]. Sago synthetic wastewater has been generated in response to the problems, and an effort has been made to break down the greater quantities of organic debris. With the awareness of the affordable technologies of aerobic therapy, attention in the aerobic reactors has quickly improved [24]. In this situation, technologies that filter water without endangering people or the environment are required to produce clean, affordable water.

Technological breakthroughs in nanotechnology provide up new possibilities for the creation of devices that might help ease water-related challenges. In order to create a sustainable water supply, it is crucial to repurpose treated wastewater effluents. In the current study, an Aerobic Bio-Reactor (ABR) investigational model was created to conduct experiments on replicated, man-made waste streams of sago to evaluate the behavior of treatment efficacy under changing experimental settings. Sorbents are frequently used in batch processes to remove excess organic and inorganic impurities.

Although nanoparticle water treatment has the potential to be used, its cost should be managed to withstand the market's current competitiveness. They convey size-dependent features such as strong reactivity, increased adsorption capability, and elevated dissolving action and can be employed in wastewater treatment because of their larger surface to volume ratio. Additionally, several distinctive qualities like super paramagnetism, semi conductivity, and the quantum confinement effect have added benefits to treatment methods. The effectiveness of common sorbents used in adsorption practice, such as activated carbon, ion-exchange resins, and others endure from a lack of active sites or high accessible face area, as well as from a be deficient in selectivity and specificity and adsorption kinetics.

Due to the much better surface area of nanoparticles, their higher specificity and selectivity, as well as their tunable pore size and surface chemistry on a mass source the use of nanomaterials (also known as "Nano sorbents") may have advantages over conventional materials (also known as "Sorbents") in order to overcome difficulties. A few nanoparticles can also be very effective adsorbents due to their distinct structure and electrical characteristics. The intention of this study is to assess the performance of ABR at different HRT and the treated effluent was again treated with the support of nanotechnology in the ambient condition with a goal of reusing the effluent.

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II. REVIEW OF LITERATURE

The reviews focused on green synthesized nano particles, aerobic wastewater treatment methods and though conflicting results have been observed from the year 2010 to 2020. The environment is highly polluted owing to rapid growth in modern industrial practice.

Those industries are exits the contamination of water into natural resources, which cause hazardous pollutants has attracted much serious attention in the last few decades. This is particularly due to toxic, acute and chronic health effects. This is partly due to increasing environmental awareness and the implementation of environmental laws. The detailed literature review on research and synthesis of Zinc nanoparticles from plant extract in various approaches has been studied. The efforts of numerous researchers have given rise to many variant and modifications of the Synthesis of Zinc nanoparticles.

Many biological approaches of green synthesis have been reported till date using plant leaf extracts from Alternanthera sessilis, Morinda citrifolia [28], Mukia scabrella, Iresine herbstii, Tribulus terrestris, Azadirachta indica, Cycas circinalis, Ficus amplissima, Commelina benghalensis, Lippia nodiflora [20], Ocimum sanctum [14] and Aloe vera.

Zargar M et al., (2011) [33] have reported that the different biological methods are gaining recognition for the production of Zinc nanoparticles (Zn-NPs) due to their multiple applications. The resulting zinc particles are characterized using transmission electron microscopy (TEM), X-ray diffraction (XRD) and UV–Visible (UV-Vis) spectroscopic techniques. The TEM study showed the formation of zinc nanoparticles in the 10–30 nm range and average 18.2 nm in size.

Awwad and Nidà Salem, (2012) [5] have reported that utilizing the reduced property of mulberry leaves extract and Zinc sulphate, Zinc nanoparticles (ZnNPs) were synthesized at room temperature. Zinc nanoparticles were characterized using UV-visible absorption spectroscopy, scanning electron microscopy (SEM) and X-ray diffraction (XRD). Further, silver nanoparticles showed effective antibacterial activity toward Staphylococcusaureus and Shigella sp.

Bhakya et al., (2015) [9] has reported as Green synthesis has now become a vast developing area of new research groups. Here we report a green method to the synthesis of Zinc nanoparticles (AgNPs) using the different parts of an ayurvedic medicinal tree. This is nontoxic, eco-friendly and low cost method. The size and structure of the zinc can be characterized by using UV–VIS spectroscopy, TEM, XRD, DLS and FTIR. The size and extract dependent catalytic activity of the biosynthesized nanoparticles is established in the degradation of organic dyes.

Sarika Singh et al., (2013) [27] have investigated that the water scarcity and its contamination with toxic metal ions and organic dyes represent a serious worldwide problem in the 21st century. Explore a broad-spectrum overview of recent developments in the area of oxide-based nanomaterials, such as Fe3O4, ZnO and TiO2, as well as their binary and ternary nanocomposites, for the removal of various toxic metal ions and organic dyes.

III. MATERIALS AND METHODS

A. Reactor Configuration

In regulate to test the treatment effectiveness of synthetic wastewater from the sago processing under a variety of experimental settings, an Aerobic Bio-Reactor model was constructed. Plexi glass made up the experimental lab model. The reactor had an operating capacity of 13 litres. Both the attached growth process and the suspended growth process are included in this model. The flow rate was managed using a peristaltic pump (PP-10EX) with variable speed. Fig.1. depicts the experimental setup's design. Characterization of wastewater was analyzed as per the APHA 2017 [4].

Fig. 1. Photographic outlook of the Aerobic Bio-Reactor

B. Preparation of Zn O nanopowder and Characterization

To make zincoxide nanopowder, 0.01% PVA solution was first made. Then, 2 ml of PVA was added to 1 ml of zinc sulphate heptahydrate solution, and 2 ml of sodium hydroxide was slowly and drop wise supplementary to it. The ensuing solution was then agitated for almost 18 hours. One thing to maintain is that if there is a high concentration of PVA, a lot of fluff will form instead of precipitate. Huge amounts of white hasty were produced after 18 hours, which were filtered, rinsed with distilled water, dried for 2 hours in a muffle furnace at 100°C, crushed into fine powders, and then calcined at 450°C [3]. The powder was exemplified by the Scanning Electron Microscopy (SEM) and the element size analysis was drawn for the intensity and the diameter of the nanoparticle. The product specification is as offered in the Table-I. The characterization of synthesized ZnO nanoparticle as Particle size analysis graphical representation is shown in Fig. 2. and the SEM image is presented in Fig. 3.

Table-I: Specification of Zinc nanoparticles

Purity	99.9%
Molecular Formula	Zn
Form	Powder
Density	7.14 g/cm³
Boiling Point	907 °C
APS	60-80 nm
Molecular Weight	65.37 g/mol
Color	Grey to black
Melting Point	419.53 °C
Solubility	Insoluble in water

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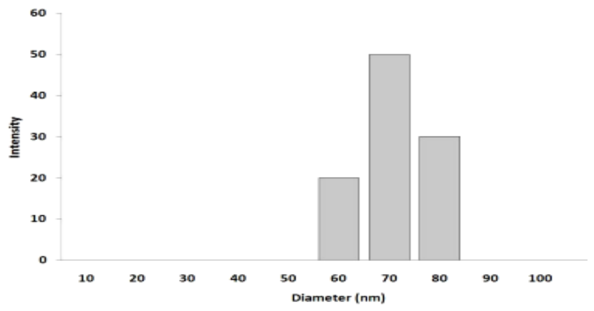

Fig. 2. Particle Size Analysis

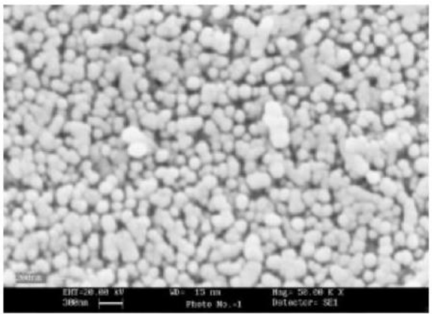

Fig. 3. SEM image of Zincoxide nanopowder

IV. RESULTS AND DISCUSSION

A.Stabilization process

The activate stage is considered as the phase taken for steady function to be attained. This is a decisive step for the constant process of the ABR and other aerobic reactors at a planned organic loading rate (OLR). In adding up, operational temperature is high up throughout start-up [26]. In this work, the ABR was operated at a temperature between 25°C and 35°C (Mesophilic range). The start-up stage of the process was instigated by incessant feeding of the reactor with an average influent COD concentration of 856 mg/l. The COD elimination rate in first two days was low down in the series of 7% to 13%. The low efficiency in removal at the launch of the process is due to the biomass version to the new environment. During the start up period the pH and DO plays an important role. The COD diminution was attained 7% in the initial stage and it was incremental up to 12th day and decline from 12th to 14th day and then attains a steady state from 15th day to 18th day with a COD deduction efficiency of 96.45%. **(Fig. 5.).**

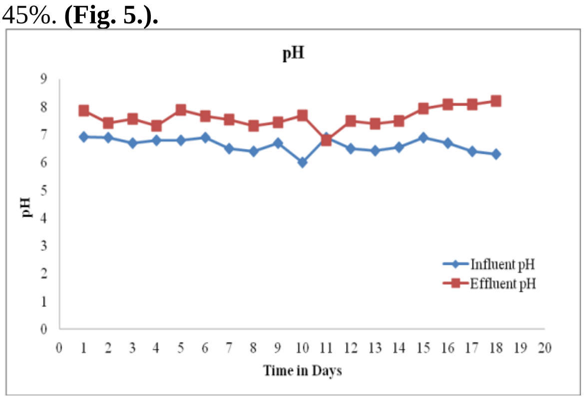

Fig. 4. No. of days' vs. pH during Start-up process

The effluent pH throughout the start-up phase is shown in Fig. 4. The effluent pH rate was from 6.8 to 8.2. These results designated a good system of buffering and non-inhibition of microorganism at the commencement of the adaptation process.

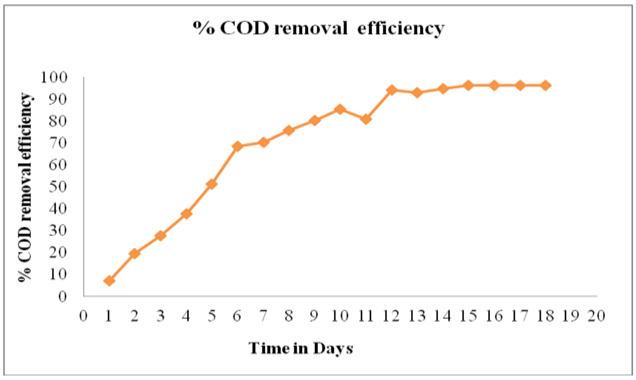

Fig. 5. No. of days' vs. % COD removal efficiency throughout Start-up process

After achieving the steady state, the reactor was slowly feeded with the sago wastewater by 20%, 40%, 60%, 80% and 100% for the experimental analysis. Figure 6 shows the effectiveness of HRT in terms of the percentage of COD elimination efficiency [23]. Due to the large amount of biomass in the model at the beginning of the progression, the deduction efficiency was not as low as it may have been, but it is challenging to keep an adequate number of beneficial microorganisms in the system [31]. In aerobic reactors, pH continues to play a key role in regulating the digestive process [22]. Although it is true that stability may be reached when the pH range of 6.0 to 8.0, it is advised to evade the pH values less than 6.0 and more than 8.3 as in these ranges, the microbes may be suppressed [10]. Aerobic bacteria can live in settings with pH values in the range of 6.6 and 7.6. The pH of the reactor was kept steady, though, and ranged between 6.8 and 8.3, which is a good range for digesting activities [19]. Due to the amalgamation of attached growth processes and suspended growth processes in a single reactor, the reactor reached a steady state condition as early as expected. With 84 hours of HRT and an OLR of 1.518 kg COD/m3, the highest COD removal effectiveness, or 91.20%, was achieved as shown in Fig. 6. In comparison to other aerobic processes, the HABR achieves additional benefits by combining attached and suspended growth processes in a single reactor and obtaining an efficiency of 91.20% for COD elimination.

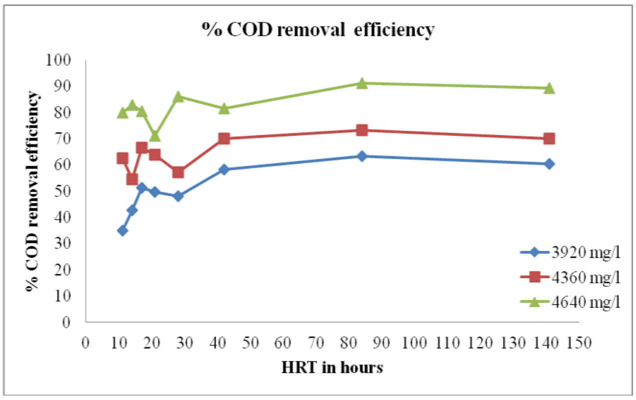

Fig. 6. HRT (hours) relating to % COD removal efficiency through an average influent COD of 3920, 4360 and 4640 mg/l

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B. Batch study as adsorption

Wastewater adsorption treatment is done right away using the batch procedure. The batch procedure is carried out in a clogged system with the ideal quantity of adsorbent in contact with the preset amount of adsorbate solution. Rotating stirrers are used to agitate the contents of a closed vessel, ensuring that all adsorbent components are well mixed with the contaminated solution. A high-quality recyclable effluent is produced following treatment by well-designed batch procedures since they are so effective. Additionally, if affordable adsorbents are utilized or regeneration is possible, a batch adsorption procedure may be cost-effective [25]. The batch adsorption method may also be applied to the quality enhancement of industrial and other wastewater as well as the source reduction of contaminants [6]. Adsorbent is combined with wastewater in the batch tank for a given amount of time and pH, after which the final adsorbate attentiveness is calculated. Depending on the needs, the batch process in industry can simply scaled up or scaled down [1]. Adsorption takes place in the batch tank when contaminants in the solution come into contact with the adsorbent [30]. Physical and chemical adsorption are both possible forms of adsorption. Van der Waals forces serve as an attractive force during physical adsorption, and the ensuing adsorption is reversible. Strong chemical bonds operate as an attraction force in chemisorption, and this adsorption is irreversible. For the experimental investigation, chemisorbent doses as zinc oxide of 0.25g, 0.5g, 0.75g, and 1.0g were utilized. The percentage removal effectiveness of COD at a dose of 0.25g of chemisorbent changes in relation to various effluent pH values. The experiment was examined using different zinc dose levels and a pH range of 1 to 14 presented in Table-II. The elimination efficiency was minimal and poor between pH 1 and 5.

C. Effect of pH on percentage removal efficiency of COD

The impact of adjusting the dose of Zincoxide chemisorbent from 0.25 g to 1.0 g on the elimination of COD while maintaining the contact time of 60 minutes to 360 minutes was examined. It is one of the crucial variables in the sorption process because it has the ability to attack the chemical form and active sites of species in wastewater solution [12]. It was discovered that the pH decreased with the reduction of physicochemical factors. In general, the clearance effectiveness was poor and insignificant in the pH range of 1 to 3. The percentage removal efficiency was likewise high when the dose of the sorbent was increased at higher pH values [29].

Table-II: Effect of pH on percentage removal efficiency of COD in treated synthetic sago wastewater by Zincoxide nanopowder (chemi-sorbent)

pH	Percentage removal efficiency of COD			
	0.25 g	0.5 g	0.75 g	1.0 g
1	12.45	13.36	15.81	11.83
2	17.68	19.63	18.59	11.45
3	21.31	28.32	29.36	17.89
4	29.43	29.94	31.35	20.32
5	37.65	33.54	42.63	30.19
6	86.91	88.78	89.96	88.96
7	98.89	99.69	100.00	99.93
8	81.67	83.73	80.38	79.36
9	73.18	72.36	71.45	68.69
10	26.65	23.21	28.46	21.34
11	22.32	28.15	28.91	21.38
12	15.29	15.83	14.14	17.76
13	19.65	18.21	19.78	12.53
14	11.43	17.54	15.38	10.24

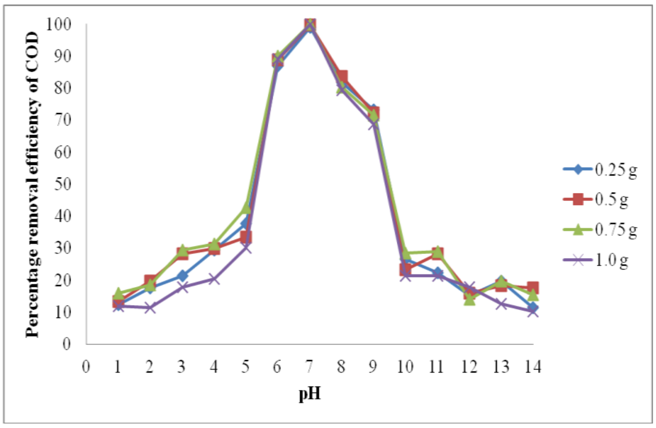

Fig. 7. Effect of pH on percentage removal efficiency of COD in treated synthetic sago wastewater by Zincoxide nanopowder (chemi-sorbent)

The results of the experimental investigation, which included pH ranges of 1 to 14, are presented in Fig. 7. The effectiveness of percentage removal for pH 1 was 15.81. In this instance, the greatest % removal efficiency was obtained at 100% at the same dose of 0.75g of chemisorbent with a pH level of 7. The clearance efficiency began to decline for the same dose (0.75g) with rising pH levels. Due to ion competition in the sorption sites, the removal effectiveness at lower pH was poor [32].

D. Percentage removal efficiency of COD with respect to the pH level of effluent (6 and 7) and dosage level of Zinc

By adjusting the zinc oxide chemisorbent dose from 0.25g to 1.0g with the contact period of 60 minutes to 360 minutes and modifying pH level, the impact of dosage content on chemisorption was ascertained [2]. From 86.91% at dose of 0.25g to 88.78% at dosage of 0.5g, the percentage elimination efficiency rose significantly at dose of 0.75g as 89.96% although it slightly fell to 88.96% at dosage of 1.0g as shown in Fig. 8. The increased ease of use of binding sites and surface area, which causes the chemisorption to be extremely simple until equilibrium is attained, is what causes the first quick rise. The aggregation or overlap of the sorption site at pH level 7 is what causes the decrease in COD. The % elimination efficiency was reached in equilibrium after 1.0g of dose content at pH level 7 [11].

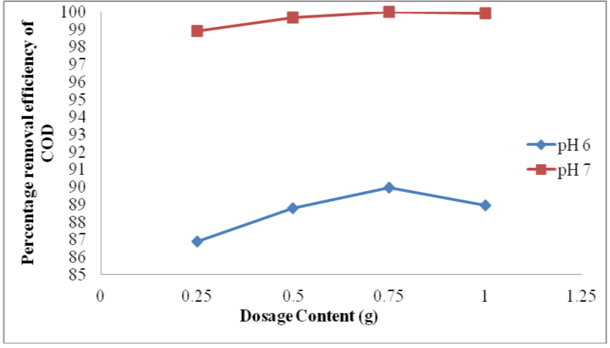

Fig. 8. Effect of dosage content on percentage removal efficiency of COD in treated synthetic sago wastewater by Zincoxide nanopowder (chemi-sorbent)

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The percentage removal efficiency improved with an increase in zinc oxide chemisorbent dose 0.25g to 0.5g, reaching 98.89% to 99.69% at 7 pH. The greatest % removal efficiency was 100% when the chemisorbent dose was increased to 0.75g while maintaining the same pH. The percentage removal efficiency dropped to 99.93 by increasing the dose of chemisorbent from 0.75g to 1.0g. Thus, at equilibrium circumstances, the % removal efficiency of more than 1.0g was achieved.

E. Effect of contact time on percentage removal efficiency of COD in treated synthetic sago wastewater by Zincoxide nanopowder (chemi-sorbent)

Contact time is also one of the most effective factors in batch chemisorption process. The chemisorption of COD by chemisorbent also depends on the interactions of efficient groups between the effluent and the surface of chemisorbent. In all transfer developments, including chemisorption, contact times are crucial parameters. Hence it is the main focus to study the chemisorption process. The contact time raises the ability of chemisorbents in the exclusion of toxic ions [11]. For pH level of 6 and 7, the contact time was varied from 60 to 360 minutes and the percentage removal efficiency of COD were analysed. By increasing the dosage of chemisorbents by 0.25g to 1.0g with varying the pH level from 1 to 14 testing were conducted to optimize the percentage removal efficiency of COD. For 0.75g of chemisorbents with pH level of 6 and 7, the percentage removal efficiency of COD was found appreciable as represented in Fig. 9.

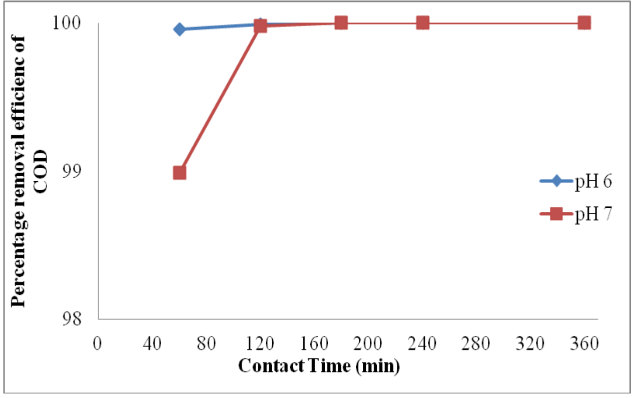

Fig. 9. Effect of contact time on percentage removal efficiency of COD in treated synthetic sago wastewater by Zincoxide nanopowder (chemi-sorbent)

V. CONCLUSION

From the above consequences, it could be concluded that by treating the sago wastewater aerobically (ABR) could reduce the organic pollutants present in it. However, the COD removal efficiency was 91.20% with an Organic Loading Rate (OLR) of 1.518 kg COD/m3 but it was not satisfied for the purpose of reuse. Hence, the batch study was conducted as a tertiary treatment with chemisorbent of zinc oxide nano powder and observed the COD removal efficiency of 100% with 0.75 g of dosage content at the pH of 6 at the contact time of 180 minutes. Therefore, it is suggested that sago wastewater can be treated efficiently by chemisorption of zinc oxide nano sorbent followed by Aerobic Bio-Reactor.

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