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Application of Nanocomposite and Factors Affecting the Photocatalytic Degradation Of Organic Pollutants In Wastewater

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Abstract - Conversion of agricultural waste to useful product especially activated carbon will reduce the demand for new resources; cut down the cost and effort to transport and production, otherwise loss to landfill. Due to abundant supply, high density and purity, brew waste is chosen; with the appropriate method of activation the widely used non-hazardous carbonbearing product "Activated Carbon" (AC) is produced. Dual surface modification namely chemical activation with sulphuric acid followed by ultrasonication clinches the properties of activated carbon. Chitosan is a second-most abundant biopolymer on earth after cellulose. Its unique properties have recently received particular attention from researchers to be used as a potential biosorbent for the removal of organic dyes. However, pure chitosan has some limitations that exhibit lower biosorption capacity, surface area and thermal stability than chatoyant composites.

Keywords - Photocatalysis, Degradation, Organic pollutant, Wastewater treatment, Heavy metals

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INTRODUCTION

Water is the most abundant resources and essential element of life which is free in nature along with air. Water is a natural detoxifier as well as the human body's most principal chemical component thus become the basic necessity to sustain life. Water is a good solvent, by virtue of it, all the harmful chemicals and pollutants get dissolved in water becoming unfit for drinking. India is privileged by 4 % of total usable water resources, housing 18 percent of the world's total pollution, yet, less accountable for the availability of water per capita per year. Groundwater depletion, lack of rainwater harvesting and rising contamination in the groundwater create fresh challenges for the low-income Indian cities or resettlement colonies for safe water due to sewage and industrial effluent discharge (World Water Development Report 2017). In fact, of the 632 odd districts of India that were examined for groundwater quality, only 59 districts were marked safe. The Government of India (GOI) estimates that 70 percent of available water is unfit for consumption without prior treatment. Substantiating this, World Resources Institute (WRI) reported that over 100 million people in India are living in areas where water is severely polluted and consumed by them with no other choice and thereby suffered from water-borne diseases such as diarrhea and gastroenteritis. Indians are the highest number of people around the globe without access to safe drinking water due to lack of hygiene facilities presented by the Water Aid, 2016. An increasing urban population with geographical diversity results failed response in linking safe drinking water to public health policy and making it available or portable for all. For instance, arid landscape of Rajasthan is facing water scarcity, further aggravated by the potassium contamination in the meager drinking water (Kate 2016). The perennial rivers in Uttar Pradesh and Bihar has become polluted with toxic chemicals. In other parts of India like Haryana, Punjab and the Yamuna belt, groundwater has been an increase in metal content and salts due to excessive use of chemical fertilizers in agriculture. Thus, water scarcity and non-availability of clean drinking water become the country's ineffective response to the treatment of water/sanitation-related diseases. World Health Organization (WHO) has documented around 1,40,000 children and 38 million people deaths in India from diarrheal diseases and other water-borne diseases. Furthermore, Water Aid has presented that among 107.42 million tap water accessible households in India, only 78.88 million households are getting treated tap water (Water Aid 2017). The treatment of tap water has no assurance of being free from all types of contaminants. A large chunk of Indian population is at the risk of water-borne diseases by exposing to tap water that contaminated with rust, cyst, sand and bacteria, dissolved salts

and chemicals. World Bank reports that the unsafe drinking water is responsible for 21 percent of communicable diseases in India. Thus, it is high time for launching a mission mode programme on safe drinking water to be prioritized in public health policy. Access to safe drinking water was declared as a human right by the United Nations but remains a challenge for urban India according to a new global report released to mark World Water Day (WWD) in 2017. Regrettably, Safe Water Network (SWN) has reported on India stands 120th position among 122 nations for water quality surveyed by the United Nations (UN). This abysmal situation in India succumbs people to waterborne diseases instead of deriving safe drinking water from sources. Therefore, safe drinking water becomes out of mundane and abundant things into exotic valuables for mankind (Chaudhry & Malik 2017).

LITERATURE REVIEW

Jyoti Yadav (2022) Most of the world's freshwater is inaccessible, there is water contamination, and there isn't enough potable water to go around. Our studies' ultimate goal is to use nanotechnology for the efficient and secure purification and treatment of wastewater. The potential uses of nanotechnology are many. Metal-based nanoparticles allow for the development of cutting-edge wastewater treatment methods. In order to remove impurities from water, adsorption, waste and dangerous material breakdown, and nanoscale filtration are often used. Wastewater treatment with nanotechnology is the primary topic of discussion in this literature review.

Das, Chanchal, (2020) From wastewater resources, we may get clean and pure drinking water by adsorbing organic contaminants, poisonous metal ions, and hazardous microorganisms. Using crude Jatropha curcas latex (JC) and Cinnamomum tamala leaf extract (CT), magnetite nanoparticles (MNPs) were produced in an outdoor setting for less money and less environmental impact. Dynamic light scattering (DLS), UV-vis spectroscopy, FTIR spectroscopy, powdered X-ray diffraction (XRD), and field emission scanning electron microscopy (FE-SEM) have all been used to characterize MNPs. FE-SEM scans revealed that the sizes of the synthesized MNPs ranged from 20 to 42 nm for JC-Fe3O4 and from 26 to 35 nm for CT-Fe3O4. Antibacterial, antioxidant, and cytotoxic properties, in addition to their role in wastewater treatment (bacterial component), were investigated, as were their effects on the adsorption of dye and the removal of hazardous metals. As a result of these efforts, there will be more clean water available in the future.

Nakkeeran, Ekambaram (2018) Toxic and possibly carcinogenic chemicals are released into water bodies from textile dye effluents including azo compounds, heavy metals such as Cu, Cd, Zn, Ni, and Pb, and other highly suspended particles. There are a number of chemical and physical methods that may be used to get rid of these impurities, but they could all need some work to become more effective. Here, we investigated the potential of zinc oxide (ZnO) nanocomposites for cleaning up wastewater from the synthetic and textile industries. X-ray diffraction (XRD) and scanning electron microscopy (SEM) were used to analyze ZnO nanoparticles that were generated using the chemical reduction process employing zinc nitrate. According to the XRD data, the typical nanoparticle size is on the order of 20 nm. SEM verified the nano-sized and spherical nature of ZnO particles. Chitosan was mixed with ZnO nanoparticles to create the ZnO nanocomposite. ZnO nanocomposite demonstrated 99% dye removal from synthetic and textile industry effluent at 30°C and pH 6 with a dose of 0.9 mg/mL at an initial dye concentration of 600 ppm. When industrial wastewater was utilized, however, the process parameters were modified somewhat. Based on the findings, ZnO nanocomposite may be useful as an adsorbent for cleaning up colours in factory runoff.

PHOTOCATALYSIS

The kinetics of the heavy metal adsorption mechanism were described by several scientific studies (Boži´c, D.; Gorgievski, et al 2013), (An, F.-Q.; Wu,2017)Most researchers could measure heavy metals and Fe together because the habitat of each element is the same. The occurrence and the fate of heavy metals (Cd, Pb, Cu, Zn and Ni) were investigated in wastewater. (Anirudhan et al., 2012) analyzed active sludge technology in the wastewater treatment plant in Thessaloniki, Greece. The six types of wastewater sludge used and analyzed for their study were taken from different points of the plant, to the inlet and outlet of the primary sedimentation tank, or only from the wastewater from the secondary settling tank. In their investigations, a strong correlation was found between the heavy metal partition coefficient (log Kp) and the suspended solid concentration . (Hayati et al., 2017) reported in their work that the phase distribution of individual heavy metals during the cleaning process changed very little. used copper and cadmium ions to activate carbon, compost, cellulose pulp and sewage sludge. Their investigations show that copper was not sealed in sewage sludge, with the other materials being successfully sealed .(Tovar-Gómez et al., 2015) demonstrated that osmotic and nanofiltration technological solutions are well-suited for sealing heavy metal content in sewage. For underlying tests, sewage samples that contained copper and cadmium were used among laboratory conditions. Their results showed that osmosis and nanofiltration efficiency were 98% for copper and 99% for cadmium . Due to the efficiency of copper removal, synthetic sewage samples decreased the average copper concentration to 3.5 ± 0.7 pap (Guiza, S et al

2017). Figure 1 shows the comparison of Langmuir and Freundlich isotherms for Cu adsorption

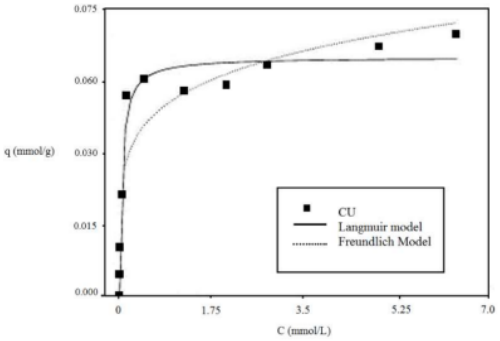

Figure 1. Demonstration of Cu adsorption mechanism by Langmuir and Freundlich isotherms .

During their investigation, two stages were conducted, using biogas residue and compost respectively. In their work lasting six days, water samples of different origins were tested, as well as samples of solid fermentation and compost which had heavy metal adsorbing properties. They found 70% efficiency for Ni, 40% for Zn and 25% for Cd. Only Cu and Pb had significant values . (Kolbasov et al., 2017) reported the biosorption potential of heavy metal contaminants using Phallusia nigra in two Indian cities. During their investigation, they focused on Cd, Cu, Hg and Pb content (Xia, Z.; Baird 2017). In Thoothukud's water, they found a higher concentration of heavy metals, than in water samples from Vizhinjam city (Zhang, Y.; Sun, J 2018). The order of bioaccumulation factors was also determined as follows: Pb > Cd > Cu > Hg (Zhao, J.; Liu, J 2016)

POLYMER NANOCOMPOSITES AS PHOTOCATALYST

Food safety is a global priority for better human health, and it is threatened by anthropogenic sources of heavy metals such as wastewater irrigation, sludge application, and industrial effluents. Therefore, heavy metal remediation of soil could prevent the transfer of heavy metals in the soil–crop system. The mechanisms of the translocation of heavy metals from soil to crops are well understood. Remediation efforts should be directed toward reducing metal concentrations in soil to minimize the subsequent transfer to crops. Remediation technologies should be environmentally friendly, rapid, and cost-effective. The remediation of heavy metals in soil can be conducted through physical, biological, ecological, and chemical approaches (Fig. 2). Innovations in nanotechnology could assist in the remediation of metallic contaminants. The H-G concept integrates human health risk assessment methods with geospatial technologies to evaluate geographical indicators, provide rapid and accurate assessment of problematic soil sites, and develop suitable remediation measures (Zou et al., 2017). Moreover, judicial land use policy alterations and land-use shifts should be applied to locate agricultural fields distant from municipal and industrial sources of heavy metals. Multifaceted strategies for raising organic food without chemical applications are beneficial to human health and have gained much popularity at the global level. However, those methods are expensive and cannot be afforded everywhere (Rock et al., 2017).

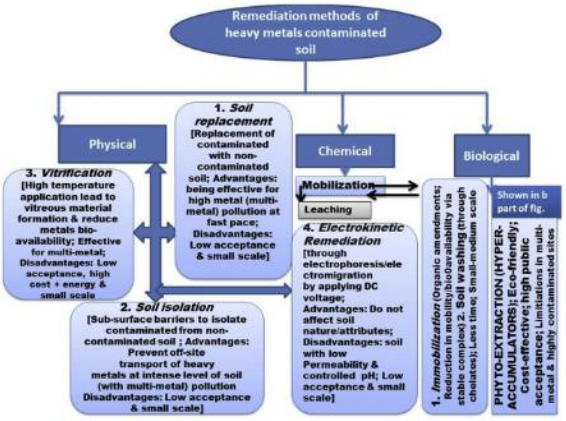

Figure. 2. Glimpses of existing tools on remediation of heavy metals in soil-food crops sub-system to mitigate human health risks.

FACTORS AFFECTING THE PHOTOCATALYTIC DEGRADATION OF ORGANIC POLLUTANTS IN WASTEWATER

The most important challenge in 21st century is to combat against ever increasing environmental pollution. These days, the world is in a cancerous grip of environmental pollution in its one or the other form, out of which water pollution is of prime concern. The chemical based industries play a significant role in human civilization but extensive anthropogenic and industrial activities have introduced large quantities of chemicals in the environment causing potential harm to many ecosystems. Among all other pollutants, dyes, pesticides, surfactants, chloro-organics etc. are important classes of aquatic pollutants and thus, becoming a major source of environmental contamination. Now-a-days, many research studies have been focused on treatment of wastewater. Because of the complexity and variety of organic compounds employed, it has become difficult to find a unique treatment procedure that entirely covers the effective elimination of all types of organic contaminants. Physical methods such as flocculation, reverse osmosis and adsorption on activated charcoal are non-destructive and only transfer the pollutants to other media; thus, giving rise to secondary pollution. Heterogeneous semiconductor photocatalysis has been extensively studied and it is a promising approach for

degradation of a large number of organic pollutants as it is also found to be cost effective. Photocatalysis finds a good scope in the field of creating renewable energy resources and also for cleaning environment. Semiconductor based photocatalysis has been extensively studied for its environmental applications and demonstrated to be a cleanup process. Heterogeneous photocatalysis is a part of Advanced Oxidation Processes (AOPs) and it is a process of great potential for pollutant degradation and waste water treatment.

Hydrocarbons

TiO2 (in its anatase form) is used as photocatalyst in the oxidation of heptane. Photocatalytic hydroxylation of aromatic ring by using water as an oxidant in the presence of platinum loaded TiO2 as also been reported. The use of supported TiO2 catalyst has increasingly attracted attention of chemists in recent years because of their potential applications to photocatalytic degradation of organic pollutants in water and air. It has also been reported that the use of adsorbents as the support for TiO2 provide good environment for removal or degradation of target substances . carried out the synthesis of different sized cuprous oxide nano-crystallites and studied their photocatalytic activity while nanocrystalline zirconia supported nikel catalysts were employed in methane reforming with CO2 for the production of synthetic gas synthesized nanosized Ti-W oxide and observed the effect of doping level in the photocatalytic degradation of toluene under sunlight excitation while iron doping in La0.7Sr0.3MnO3 (organo resistant pervoskite) was reported .Photocatalytic degradation of naphthalene over TiO2 in the presence of inorganic anions was studied .The effect of parameters such as concentration, light intensity, temperature, pH and mass of catalyst was observed. The optimum concentration of titania was 2.5 g/L. It has been found that small amounts of carbonates strongly inhibit naphthalene adsorption and degradation. carried out a comparative study on decomposition of gaseous toluene by O3/UV, TiO2 /UV and O3/TiO2/UV. Marci et al. also reported the photocatalytic oxidation of toluene on irradiated TiO2 while .investigated oxidation of light alkanes over titania supported palladium/vanadium catalyst. observed the photocatalytic degradation of 1,4–dioxane in TiO2 suspension.

Alcohols

The photocatalytic oxidation of n–butanol under fluorescent visible light lamp over commercial TiO2 (Degussa P25) has been observed .Under fluorescent visible light lamp, n-butanol (550 ppm) was completely mineralized over both the commercial TiO2 (Hombicat UV 100 and Degussa P25). Steady state conversions of less than 95 % are attained for 580 ppm but at 145 ppm, complete mineralization is achieved. Thermal treatment of TiO2 at ≥ 623 K has an adverse effect on the photocatalytic activity of both catalysts. prepared V–doped TiO2 photocatalyst and used it for photoxidation of ethanol in visible light. It is believed that under visible irradiation, the vanadium center donates an electron to the TiO2 conduction band, which allows the oxidation of surface absorbed molecules. Heterogeneous photocatalytic dehydrogenation of ethanol over TiO2 has been reported studied the photocatalytic oxidation of some selected aryl alcohols in acetonitrile.

CONCLUSIONS

This work reviewed the results achieved by numerous researchers on the removal of organic dyes through biosorption process. The aim of this review is to present the potential of utilisation chitosan composites as low-cost adsorbent for textile wastewater treatment and to attract more research on large scale applicability. Biosorption using chitosan-based adsorbent stands out as one of the most attractive organic dyes removal methods in terms of cost-benefit and efficient performance. The utilisation concept of converting waste to wealth can promote sustainability in the wastewater treatment research field. The study emphasizes to optimize resources utility and processes involved with the production of active carbons with prescribed surface properties (microporous structure) and specific end uses from biodegradable waste. Waste to carbon conversion process, can significantly reduce the grounded waste volume produced in the commercial industry or the domestic waste, eliminate the need for further treatment, reduce the cost of landfilling and transportation. The non-incinerated carbonaceous material was treated with dehydrating or oxidizing chemical like sulfuric acid which is leached out. Chemical activation was favorable on lignin-based starting materials, producing macroscale pores that are greater than 100 nm in size

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