

Preface

Water pollution is defined as the contamination of water sources by contaminants that render the water unfit for drinking, cooking, cleaning, swimming, and other uses. Chemicals, waste, germs, and parasites are all examples of pollutants. All types of pollutants ultimately end up in water. Pollution from the atmosphere settles on lakes and seas. Pollution from the land can flow into an underground stream, then into a river, and eventually into the ocean. As a result, rubbish thrown on an empty lot might ultimately damage a water source.

Human activities generate wastewater, which may be harmful to the environment and result in water loss in areas where water is limited. When wastewater contaminates rivers and groundwater tables, the water resource is rendered useless. As a result, wastewater must be treated before it is discharged into the environment, and if feasible, treated to make it drinkable.

The goal of wastewater treatment is to decrease pollutants to fewer than the maximum allowable levels in order to protect the environment and human health. To do this, wastewater is collected and processed in massive plants before being discharged back into the environment. Water that goes into drains or the sewage system from dwellings is referred to as wastewater. Large amounts of wastewater are routinely contributed to sewage collecting systems by industries and enterprises.

The discovery of new and novel materials capable of improving the efficiency of industrial wastewater treatment processes, and even the manipulation of these materials' characteristics to increase pollutant recovery, has made steady progress. Secondary effluents including heavy metals and radionuclides are produced by anthropogenic activities such as mining, manufacturing, and energy generation. Given their potential influence on water quality, the development of innovative technologies aimed at recovering such pollutants is a top priority. Adsorption is regarded a useful approach in water pollution prevention because of its basic design, universal nature, high efficacy, and ease of operation and regeneration.

We seek articles in this book that highlight research findings in the creation of novel materials for the removal of soluble forms of hazardous chemicals, dyes, and heavy metals. Aside from the scientific originality of the recommended materials, the authors should underline the possibility of implementing their technique in full-scale facilities working under actual liquid effluent treatment circumstances. We accept contributions from several disciplines of research in this book, including material science, chemical engineering and processing, chemistry, adsorption, and photochemistry.

The focus of this book is the production of novel materials (bulk, composites, and hybrids) through the improvement/transformation of certain wastewater treatment procedures. Papers on the following themes will be given special consideration among the areas of interest:

- Development of novel procedures for the synthesis of nanomaterial, nanocomposites, carbon-based nanomaterials, and other nanomaterials by fine-tuning synthesis conditions to get the optimum adsorption characteristics;
- Innovative composite materials are being developed for use in liquid-phase adsorption processes.
- Elaboration of bio-sourced materials (biochars, hydrochars, chars, activated carbons) from various biomasses or carbon materials for the particular removal of dyes, hazardous chemicals, and heavy metals;
- High selectivity polymers or polymer composites are being developed.

SOLUTION

The efforts of scientists are the key driving force behind nanotechnology innovation, via the assessment of the techniques used to generate Nano materials for water and wastewater treatment, and these technologies must be demonstrated in the future. Without a question, nanoparticles have played a significant role in the advancement of wastewater treatment technology. To minimize the possibility for these nanomaterials to become a source of environmental contamination, researchers must concentrate understanding of the related negative hazardous and environmental effects. Effective learning in the use of nanotechnology for sustainability may be a critical step in developing learning experiences that cultivate the knowledge and skills required to drive change in a sustainable manner.

BOOK ORGANIZATION

In this book, we have selected the 15 research and review articles for publication. The chapters in this book reflect a wide range of fundamental and applied research in water and wastewater treatment by the nanomaterials and interdisciplinary subjects. This book is a unique collection of full research papers as well as reviews.

In the 1st chapter, the photoelectrochemical water splitting process as well as the photocatalysis process for pollutant degradation of BVO photoanode has been discussed. Growth of visible light active efficient and stable photocatalyst can degrade pollutants with an environmental impact. Since the BVO-based semiconductors can be activated under visible light irradiation, these materials would gain much popularity, especially for in water splitting process as well as degradation of pollutants in air and surface water.

In the 2nd chapter, describes a proficient method for synthesis of TiO_2/PPy and $\text{TiO}_2/\text{PPy}/\text{GO}$ nanocomposites. The Photocatalytic degradation of Rose Bengal and Victoria blue dye was done at different condition viz concentration of dye, time of illumination, pH and dose of photocatalyst. The maximum photodegradation were found at 7 pH, 20 ppm concentration of Victoria blue and 25 ppm of rose bengal dye solution, 800 mg/L for VB and 1600 mg/L for RB amount of photocatalyst and 120 min irradiation of visible light.

In the 3rd chapter, as an efficient photocatalytic materials, MXene offers rapid photogenerated charge carrier isolation, thereby providing plentiful availability for surface functional groups in respect of light-harvesting promising materials, and additionally executing a suitable foundation in favour of superior photoconversion proficiency. This chapter summarizes a comprehensive analysis of recent studies on fabrication method for MXene-based photocatalysts and photocatalytic performance for contaminant

degradations. More significantly, MXenes are frequently employed as cocatalysts to boost the efficacy of photocatalytic activities when combined with other traditional photocatalysts such as metal oxide, metal sulfide, $g-C_3N_4$ and so on.

In the 4th chapter, heavy metals have come up as a threatening pollutant in aqueous media, leading to life threatening consequences. Biomaterial has been a novel and innovative wing of Green Chemistry, eradicating the threats in a cost effective and clean manner. The present study has been focused on the successful removal of a life threatening heavy metal Cd (II) from aqueous solution, using biosorbent created using selected plants. The present study establishes the fact that carboxylic acid group plays an important role in the metal binding process using protection of COOH group by propylamination and Esterification. We could also conclude that the enrichment of COOH group onto the biomaterial using synthetic modifications Succination leads to the increase in the sorption efficiency.

In the 5th chapter, describe 2D materials, intensive efforts have been devoted in recent years. The daunting quest for unique 2D materials remains ongoing and is primarily intended to discover novel 2D materials and their remarkable properties. In this chapter, we aimed to represent a thorough analysis of the latest innovations made in the field of photocatalytic degradation by 2D materials. In addition to current progress in photocatalysis, a throwback of basic knowledge is outlined. Various combination of fabrication methods employed for preparing novel 2D NMs is also illustrated. It is widely believed that 2D materials exhibit excellent photocatalytic performance. The potential for various 2D nanomaterials has been reported at length to remediate aqueous systems contaminated with dyes.

In the 6th chapter, cellulose is a biodegradable, non-toxic, low-cost material that can be found in a wide range of natural resources and agricultural waste. To remove a variety of impurities, including harmful metals and dyes, cellulose could be used in a variety of water treatment methods. As a result, due to their high surface area, light stability, and low toxicity, the application of cellulose-metal oxide composite as an efficient dye adsorption and photo degradation in water. Incorporation of metal oxide into cellulose improves the stability of the material, prevent desorption of the nanoparticles into the water system, reduce toxicity effects and also helps the material to be long-lasting. Moreover, multi-metal or polymetal oxides can be used with the cellulose instead of pure metal oxides in the composites. Overall, when all procedures are relatively safe, would exhibit less aggregation and offer advance dye removal from waste water purification process.

In the 7th chapter, biopolymer-based nanocomposites, particularly chitosan, cellulose, alginate, starch, and carrageenan, are increasingly being employed as reinforcements for composite materials because they are biodegradable, recyclable, renewable, abundant, conveniently available, cost-effective, and non-abrasive to processing equipment. These biopolymer nanocomposite materials are also lightweight, stiff, and have good mechanical properties. Biopolymer nanocomposites have interfacial limitations because all nanocomposite biopolymers are hydrophilic. Water recycling has been made possible by biopolymer-based nanocomposite materials, which have a variety of applications for cleaning wastewater, making it a viable and cost-effective solution to water scarcity. The growing concern about heavy metal contamination has necessitated the development of new and better-suited sorbent materials for effective detoxification.

In the 8th chapter, the $TiO_2/PAni$ and $TiO_2/PAni/GO$ nanocomposites were prepared by one-step in situ oxidative polymerization of aniline hydrochloride using ammonium persulphate as oxidant in the presence of powder of TiO_2 nanoparticles cooled in an ice bath. The obtained nanocomposites were characterized by XRD, TEM, SEM, BET, FTIR and DRS. The obtained results showed that TiO_2 nanoparticles have been encapsulated by PAni. The FTIR characterisation confirms that the TiO_2/GO molecules are well combined with polyaniline structure. The maximum photodegradation of Thymol blue was found

in $\text{TiO}_2/\text{PAni}/\text{GO}$ at 25 ppm concentration of dye, 1600 mg/L amount of photocatalyst, pH 7 and 120 min irradiation of visible light. Hence, the photocatalytic activity of Titania has been increased by the coating of PAni and Graphene oxide.

In the 9th chapter, carbon nanotubes (CNTs) have the potential to support point of use-based treatment approach for removal of water hardness, chemical, and biological contaminants from water. Generally, CNTs exhibit higher adsorption capacities in the removal of heavy metals, dyes and emerging contaminants relative to other adsorbents. This is attributable to their fibrous shape with high aspect ratio, large surface area and well developed mesopores. The relatively high cost of CNTs stands as a major constraint towards application of CNTs on industrial scale for water purification. Additionally, the release of contaminant-laden unrecovered CNTs into the environment and concomitant human exposure to CNTs remains contentious due to the associated health risks. Adsorbent recovery strategies need to be further explored including the use of life cycle assessment (LCA) tool in adsorption studies both at laboratory and pilot scale experiments.

In the 10th chapter, in today's world of developing technologies, the technique of microencapsulation is applied in most the fields. It's become a prominently effective technique which reinforces the property imparted to the material and assures its durability. It's fascinating that our clothing is now ready to actively moisturize, heal and even can release fragrances to scale back anxiety. The growing health awareness among consumers is further propelling researchers to undertake and test all possible ingredients to deliver expected performance. New materials are being explored and a serious shift is towards the utilization of organic compounds both in sheath and core. There's little question that this technology features a promising future, however, one aspect that seems critical is that the intended delivery of the encapsulated core on particular external stimulus. There's a requirement to optimize the methods of manufacturing microcapsules and extend the time period of treated materials to realize large scale industrial production for every specific application. A huge use of this system is often witnessed in functional finish fabrics, medical and healthcare textiles, aromatherapy, cosmetic textiles and lots of more.

In the 11th chapter, carbon nanotubes (CNTs) are a unique carbon material. Because of their unique physical, chemical, and electrical characteristics. CNTs show tremendous promise as a viable material for usage in various environmental sectors when evaluated for specific uses. When it concerns identifying atmospheric toxins, carbon nanotube-based detectors offer great sensibility and precision, along with carbon nanotubes displaying the ability for adsorption to remove impurities with great rates and excellent amelioration competency. Carbon nanotubes have made essential contributions to a responsible future in wastewater treatment, air pollution management, biotechnologies, nanosensors, and sorbents. Carbon nanotubes are also utilized as a reinforcing material in green nanocomposites, which are essential for achieving desired characteristics and are ecologically benign. The utilisation of carbon nanotubes as hybrid filters, nano sensors, sorbents, and other materials is covered in this article, as well as its advantages for the environment.

In the 12th chapter, nanotechnology is broadly used in the different fields of science such as biomedicine, pharmaceuticals, electronics, diagnostic instruments, and environmental detection. Nanoparticles have great potential to purify wastewater and decontaminate wastewater. Nanoparticles can eliminate inorganic/organic pollutants, heavy metals, and chemical dye from contaminated water. Nanoparticles are synthesized with various methods such as physical, chemical, and biosynthesized. Plant extract is used for the synthesis of metallic nanoparticles because plant extract contains different types of primary and secondary metabolites. These metabolites act as stabilizing and reducing agents in the synthesis of novel metallic nanoparticles. The size and shape of nanoparticles have unique properties thus they

are widely used for removing pollutants from water. The chapter discussed green synthesized metallic nanoparticles and their application in the treatment of wastewater treatment.

In the 13th chapter, we have discussed briefly about the various types of nanocomposites and its role in pollution prevention. As stated in the introduction, increasing population and rapid industrialization causes a serious threat to the environment by water pollution. The effluents from dye industries are a serious problem, which can be solved to some extent by science and technology developments. Various types of nanomaterials and nanocomposites play a very vital role in dye degradation. Nanocomposite preparation characterisation, degradation methodology and its efficiency towards degradation of various types of dyes are discussed in this chapter.

In the 14th chapter, water is a vital component of life, it naturally available as earth hydrosphere and play an important role in world economy and it essential for balancing of the ecosystem. Numerous microbes and other toxins such as chemicals and heavy metals are integrated into rainwater and flowing water, resulting in water pollution. This chapter examines the numerous ways in which nanomaterials can be used to remove various kinds of contaminants from polluted water. In this chapter, carbon-based adsorbents material that is carbonaceous materials has described. Carbonaceous materials such as stimulated carbon, carbon nanotubes and graphene oxide have good performance and high adsorption value for medicinal active chemicals. In present-day investigations, researchers have found that carbon-based nanomaterials have been located progressively being applied in recycling of wastewater treatment research, with overwhelmingly positive results.

In the 15th chapter, the word nano is from the Greek word 'Nanos' meaning Dwarf. It is a prefix used to describe "one billionth" of something. A nanometre (nm) is a billionth of a meter or a millionth of a millimeter. This chapter started with an Introduction to Nanoscience then what is nanostructure and its Applications of Nanotechnology (basic idea), various size-dependent properties of nanomaterials. In this chapter some unique properties like a) Semiconducting nanoparticles b) Metallic nano-particles are explained with examples. Synthesis aspects of nanomaterials also need to understand using Bottom-up and Top-down approaches include mechanical alloying, shape and size control of nanomaterials. In the current scenario, the research and development of nanotechnology is very active globally, and nanotechnologies are already used in many products, Further, nanotechnologies are also being developed for use in environmental applications, e.g., clean-up of environmental pollutants.

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