Abstract

All forms of life present on the earth, from the lowest living things to the most sophisticated and advanced human systems, depend on water for their living. A major constraint perhaps the most significant factor hindering growth in many regions of the world is the shortage of fresh drinking water, scarcity of water for use in industry and agriculture, and for a plethora of other activities where water is inevitable. Harmful chemicals and volatile substances released from industries such as oils, arsenic, fluorides and mercury has increased at an alarming rate. Sands, silts and other such substances although do not have any direct effect on the human health but alters the natural property of water. There are various sources of this oil-contaminated waste water that contaminates the fresh water reserves. Some of the most common sources include: 1) Produced water from the oil exploration fields, 2) Petrochemical industries, refineries, 3) Metal processing industries, 4) Automotive and 5) Chemical manufacturing industries viz. textile industries, heavy metal industries, paint industries, leather industries, food processing industries. The use of conventional methods of water treatment like skimming, floatation, gravity settling, filtration etc. are inefficient in separating oils from oil-water suspensions.

Absorption has been found to be the most efficient method for treating oil contaminated wastewater. Various materials having hydrophobic character has been widely used in the removal of oils from wastewater. Various naturally occurring absorbents has also been utilized in this process of wastewater treatment like kapok fibre, cotton fibres, bagasse and other agricultural wastes, however, these absorbents have not been extensively used because of their low hydrophobic character and poor oil/water selectivity. Numerous natural materials have also been studied to determine their oil absorption capacity. These include activated carbon, wool fibres, zeolites, straw, etc. But due to their low absorption properties and poor reusability they are not abundantly used in wastewater treatment.

Polymeric absorbents have proven to be the utmost effective strategy to eliminate oils and other organic impurities from contaminated water. This work investigates the efficiency of Poly (ethylene-co-vinyl acetate) based absorbents in removing oils and organic solvents from wastewater. Further it also investigates the use of NaCl as porogen to improve the porosity of the absorbents which further increases the absorption capacity of the absorbent. Another aspect of this work is related to the use of nanoclay to prepare poly (ethylene-co-

vinyl acetate) based absorbents which also showed excellent absorption capacity in various oils and organic solvents.

Poly (ethylene-co-vinyl acetate) or EVA is a thermoplastic copolymer consisting of different compositions of ethylene and vinyl acetate. Depending on the ethylene and vinyl acetate (VA) content this polymer exhibits different properties like melting point, crystallinity, stiffness and polarity. EVA has been widely used as an encapsulation material having superior properties in wire coating, drug delivery and footwear applications due to its higher tensile strength, wear and tear properties with low hardness.

The primary body of this thesis is divided into six chapters. The introduction part is included in **Chapter 1** outlines the various methods used for wastewater treatment, materials used in preparing absorbents for absorption of oils from wastewater, materials used in the current research work and their properties. The methods, results and discussion of the current investigations have been discussed in **Chapter 2, Chapter 3, Chapter 4 and Chapter 5**. The conclusion and future scope of this thesis are discussed in **Chapter 6**.

Chapter 1: Introduction

This chapter deals with the general introduction and literature review of the current work. The importance of treating oil-contaminated wastewater has been discussed in this chapter. The various methods for treating oil-contaminated wastewater have also been outlined in this chapter. The basic concept of absorption, materials investigated for preparing absorbents and characteristics of a good absorbent has been discussed in this chapter. The various components used in this work to prepare the oil absorbents and their physical and chemical properties has also been discussed in detail. Finally, the objective of the current investigation is presented.

Chapter 2: Removal of organic solvents and oils from wastewater by absorption with crosslinked Poly (Ethylene-co-vinyl acetate) modified by cetyl alcohol

In this first investigation on the oil absorption capacity of Poly (ethylene-co-vinyl acetate), a novel crosslinked Poly (ethylene-co-vinyl acetate) (EVA) based absorbent was prepared by the grafting of maleic anhydride (MA) and cetyl alcohol (CA) in the presence of benzoyl peroxide (BP). Although EVA has been widely used in various applications like drug delivery, encapsulation, and footwear industry, however, its application in environmental remediation has not been studied in detail. In this study, melt mixing was carried out in the

Brabender mixture at 120^0C. The grafted polymer was post-cured in the hot air oven at 100^0C for 24 hours. The post-cured sorbent showed excellent absorption capacity in Toluene (2200%), Gasoline (1720%), Crude Oil (1105%), and Kerosene (390%). The contact angle measurement reveals its hydrophobic nature (123^0). The absorption properties of this hydrophobic composite remain stable even after 10 absorption/desorption cycles with absorption capacity remaining constant. The crosslinked polymer was characterized by FTIR, XRD, TGA, and SEM.

Chapter 3: Development of Porous Crosslinked Absorbents and Studies on Their Oil Removal Efficiency

In this novel study, an attempt has been made to prepare porous crosslinked poly (ethylene-co-vinyl acetate) polymer (C-EVA). The porous C-EVA was prepared by grafting of maleic anhydride and cetyl alcohol onto the polymer backbone with addition of NaCl as porogen in the brabender mixture at 120^0C and 80 rpm. This was followed by leaching of NaCl with water extraction to generate a highly porous polymer structure which was evident from its SEM micrographs. The polymer was found to have excellent swelling capacity in various oils and organic solvents and showed good selective absorption capacity. The reusability of the synthesized polymer was studied and it was found that it could be reused for more than 30 absorption desorption cycles without undergoing much change in its absorption capacity. The cross-linked polymeric composite was further characterized by FTIR, TGA, XRD, and SEM.

Chapter 4: Development OF NANO ABSORBENT USING Poly (ethylene-co-vinyl acetate)

To enhance the elimination of oils and other organic solvents from waste water, poly (ethylene-co-vinyl acetate was blended with organically modified montmorillonite (OMMT) nanoclay following a green pathway by melt blending in the Brabender plasticoder. The nanocomposites thus prepared were found to have excellent absorbing capability in various oils and organic contaminants. To further increase the absorption capacity of the nanocomposites NaCl was added as porogens in the melt mixing process, which was followed by leaching of NaCl in water to generate a highly porous nanocomposite material. The absorption test also revealed excellent absorption efficiency in various oils and organic solvents with absorption capacity of 40 g per gram of absorbent in dichloromethane (DCM) and 9 g per gram in gasoline. The nanocomposites also demonstrated excellent recycling capability and could be reused for more than 30 absorption-desorption cycles. FTIR, XRD, SEM, TEM analysis was conducted to delineate the structure and morphology of nanocomposite.

Chapter 5: Desalination of wastewater using Ion exchange method

In this study, a novel integrated ion exchange resin system has been developed to remove salts from waste water. Amberlite IR 120 and amberlite IR 400 has been used as the cation exchange and the anion exchange resins respectively which exchanges the cations and the anions from the wastewater and consequently makes the water free from salts. The adsorption isotherms for Langmuir as well as Freundlich model were studied and the adsorption kinetics thus established. Amberlite IR 120 and Amberlite IR 400 showed excellent adsorption potential of 161.29 mg/g and 233.64 mg/g respectively. The regeneration of the resins was also studied and it was found that the resin system could be used multiple times in the desalting process. The resins were further analysed by FTIR and EDX.

Chapter 6: Conclusion

This chapter highlights the summary of the overall work under investigation as well as the future scope of the current investigation.