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# Adsorbents for removal of hazardous organic substance from waste water and natural water samples: A review

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**Abstract**
Water is very important for the human body and all the living organisms, the toxicity of water due to hazardous organic contaminants/pollutants has adverse effect on aquatic life, immobilize the enzymes in plants and Causes various hazardous diseases in human being. Some illnesses do not appear after drinking or consuming unsafe water for several days, but those diseases lead to step-by step damage to human organs such as liver, lung, bladder and kidney. There is no doubt that poor quality drinking water poses a threat to human health. The hazardous organic contaminants drained in waters from different sources decreases the quality of drinking water making it toxic and non-drinkable. This is why it is essential to remove these hazardous organiz substances. Recently, various methods like membrane separation, chemical treatment, electrochemical regeneration, coagulation, flocculation, flotation, evaporation, biological purification and ion exchange are being used to remove these hazardous organic from contaminated water.

**Keywords:** waste water, adsorbents, hazardous organic substances

## Introduction

Water is very important for the human body and all the living organisms, the toxicity of water due to hazardous organic contaminants/pollutants has adverse effect on aquatic life, immobilize the enzymes in plants and Causes various hazardous diseases in human being. The textile industries, personal care products, Pharmaceutical, herbicides/pesticides, phenolics, dyes, and aromatics (from sources such as spilled oil) are the main causes of water toxicity. Recently, various methods like membrane separation, chemical treatment, electrochemical regeneration, coagulation, flocculation, flotation, evaporation, biological purification and ion exchange are being used to remove these hazardous organic from contaminated water. Among these methods, the adsorption technique has attracted much attention because it is a simple, low-cost and effective method for the removal of hazardous organic contaminants. Recently researchers are looking for the synthesis and design of a suitable adsorbent that is sufficiently stable in acid and alkaline medium and capable of having a high adsorption capacity against contaminants [1-5].

## Adsorbents for Removal of Organic substance

The Functionalized graphene aerogels (FGAs) synthesized by graphene aerogels and poly (dimethylsiloxane) (PDMS) have superhydrophobic, superoleophilic properties and mesoporous structure with a high surface area (157 $m^2/g$).The FGAs has a high absorption capacity (48–96 g/g), high separation efficiency (≥99%), ultrafast removal (a few seconds) and good recycling performance toward multiple hazardous organic substance viz dichloromethane, chloroform, toluene, n-hexane, petroleum ether present in wastewater [6]. The Coffee ground powder (CGP) have been used as an efficient adsorbent for the removal of Rhodamine dyes (i.e. Rhodamine B and Rhodamine 6G) from wastewater by batch adsorption experiments. By the help of Langmuir model the maximum adsorption capacities for Rh 6G andRh B were found to be 17.369 and 5.255 μmol $g^{-1}$, respectively [7].

The cysteine-based biodegradable surfactants are used to treatment of water containing Per/ Poly Fluoroalkyl Substances (PFAS).The removal efficiency for perfluorooctanoic acid (40 mg/L) by this surfactant was found to be 72%. The $^1$H NMR, FT-IR, elemental analysis, melting point, and critical micelle concentration (CMC) data show its adsorption behavior [8].

The Surface hydrolysed keratin protein fibers based bio material obtained by controlled hydrolysis of merino wool fibers which have free amine and carboxylic surface functional groups is used to efficient removal of hazardous dye waste from water, in the presence of 3.5% acetic acid it show maximum adsorption capacities (294 mg/g) for removal of ~95% of carcinogenic Rhodamine B dye, at 298 K [9].

The synthesized nickel(II) oxide nanoparticles is used to remove methyl orange dye from the aqueous solution by batch adsorption approach, at pH 6 it remove 95.22% methyl orange with 0.05 g dose by adsorption. Characterization of synthesized nickel (II) oxide nanoparticles has been described by advanced analytical techniques such as Fourier-transform infrared spectroscopy, selected area electron diffraction, field emission scanning electron microscopy, transmission electron microscopy, elemental mapping analysis, X-ray photoelectron spectroscopy, energy-dispersive X-ray spectroscopy and X-ray powder diffraction [10].

Due to designable pore structures, huge porosities and facile modification of metal-organic frameworks (MOFs) are used to adsorption of herbicides/pesticides, dyes, phenolics, and aromatics pollutants from water. The basic principle involved in this technique is based on the interaction such as acid–base interaction, electrostatic interaction, hydrogen bonding, hydrophobic interactionand π–π stacking/interaction developed in between organic substance and MOFs [11].

Zeolite (H-ZSM-5) nanorods decorated graphitic carbon nitride nanosheets (H-ZSM-5/g-C3N4) are used for removal of ~ 99 and 98% of Rhodamine B and crystal violet dyes, respectively. The characterization of these zeolite/g-$C_3N_4$ nanocomposites has been described by the help of XRD, FT-IR, DRS-UV, TEM, SEM and BET [12].

For the removal of methylene blue dye from wastewater, cucumis sativus peel (CSP) waste is an efficient low-cost adsorbent. The adsorbent was characterized by Scanning Electron Microscopy (SEM) and Fourier Transform Infra-Red (FTIR) spectroscopy; the adsorption kinetics follows the pseudo-second order kinetics and Thermodynamic data shows that the adsorption process is exothermic and spontaneous in nature [13].

Cellulose acetate (CA)/organo-montmorillonite (OMMT) composite has been found to have an adsorption capacity of 85.7 mg/g to remove acid scarlet G dye. The resulting composite samples were characterized by using X-ray diffraction, Fourier transform infrared spectroscopy, scanning electron microscopy, and thermal gravimetric analyses; As decreases the ratio of CA to OMMT and the pH value of the dye solution, the adsorption capacity of the composites increases [14].

The zirconium-based metal–organic framework (PCN-777) exhibits a high adsorption capacity of 442.48 $mg \cdot g^{-1}$ for cephalexin removal from water. The basic principle involved in this technique is based on the electrostatic interaction and coordination interaction between MOF framework and cephalexin [15].

Cadmium ion form water stable metal–organic clusters such as $[Cd_4(Hpda)_4(\mu_2\text{-}OH)_2(Cl)_2(H_2O)_6].2H_2O$ and $[Cd_2(pda)_2(H_2O)_6].(H_2pda)_2$ where $H_2pda$ = 2,6-pyridine dicarboxylic acid, these metal–organic clusters show adsorption capacity towards cationic dye viz Rhodamine B [16]. The corks of Quercus cerris and Quercus suber trees have biosorption efficiencies for Removal of pesticides viz atrazine, fluazifop-P-butyl, lactofen, lambda-cyhalothrin and chloropyrifos from water. The removal of pesticides follow pseudo-second order and pseudo-first order adsorption kinetics and the results show that the highest adsorption efficiency (70-80%) of the pesticides was found at pH 3, 30 °C and 360 minutes [17]. 8 mol% yttria-stabilized ZrO2 (8YSZ) nanofiltration (NF) membranes have been synthesised by size-controlled spherical ZrO2 nanoparticles with a diameter of around 10 nm and a particle roundness value more than 0.90, and the membranes were efficiently fabricated by a reverse micelles(RMs) mediated sol-gel process, the removal rate of carbofuran pesticide by 8YSZ NF membranes were found to be more than 82% [18].

A molecularly imprinted TiO2 photocatalysts, synthesized through the sol-gel technique have been used for selectively adsorb (through the molecular imprinting process) and degrade (through the photocatalysis) the specific organic substances such as herbicide 2,4D, and insecticide imidacloprid from water [19].

Two different zeolite imidazole frameworks (ZIF-67 and ZIF-8) based on two different metal ions (cobalt and zinc) are used for the removal of two common pesticides, prothiofos and ethion from water. The maximum adsorption capacities of prothiofos onto ZIF-8 and ZIF-67 were found to be 366.7 and 261.1 mg $g^{-1}$, respectively whereas; the maximum adsorption capacities of ethion onto ZIF-8 and ZIF-67 were found to be 279.3 and 210.8 mg $g^{-1}$, respectively [20]. The chemically and thermally treated watermelon peels (TWMP) are used for the removal of methyl parathion (MP) pesticide from water and the maximum adsorption efficiency were found to be 99%. The Dubinin–Radushkevich (D–R), Freundlich and Langmuir adsorption isotherms are helpful for calculation of Adsorption data and thermodynamic parameters show that the adsorption is spontaneous and endothermic in nature [21]. The Activated Coconut Charcoal (AcCoC) has been used to adsorptive removal of an organophosphorus pesticide monocrotophos. At pH 7.0 the maximum adsorption capacity to remove monocrotophos from water were calculated by Langmuir isotherms is found to be 103.9 mg $g^{-1}$ [22].

## Conclusions

In this review paper we have summarized and highlighted several adsorbent for removal of Hazardous Organic substance (viz dichloromethane, chloroform, toluene, n-hexane, petroleum ether, dyes and pesticides) from wastewater/water. The structure and surface morphology of the synthesized adsorbent have been characterized by various techniques such as FTIR, SEM, TEM, TGA and XRD. By the help of adsorption isotherms (viz Freundlich, Temkin and Langmuir) determine the maximum removal efficiency of the adsorbent for Hazardous Organic substance. The kinetics study shows the rate of the adsorption process and the Thermodynamic study showed that the processes were feasible and spontaneous. The basic principle involved in these removal techniques is based on the force of attraction developed between Organic substance and the adsorbent surface. The effect of various parameters such as temperature, pH, initial concentration of heavy metal ions, contact time, composition, co-existing ions and adsorption dose on the adsorption process of Organic substance have also been studied.

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