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STUDY ON DESALINATION AND CRONTROLLING OF HEAVY METAL ION POLLUTION USING GRAPHENE OXIDE

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ABSTRACT

Fresh water is most suitable to be converted into potable water but however most of it is inaccessible and the sources of fresh water are fast depleting due to various human activities, Desalination of sea water using Graphene Oxide (GO) can serve as the future of water source to ever growing population in the most efficient way possible. Removal of heavy metal ion pollution from the industrial waste using GO to reduce harmful effects.

Keywords:*Graphene Oxide, Selective Holes, Hydrophilic, Hydrophobic, Heavy metal ion*

I. INTRODUCTION

1.1 Fresh water availability

Water is a transparent, tasteless, odourless, and nearly colourless chemical substance, which is the main constituent of Earth's streams, lakes, and oceans, and the fluids of most living organisms. It is vital for all known forms of life, even though it provides no calories or organic nutrients. Water moves continually through the water cycle of evaporation, transpiration, condensation, precipitation, and runoff, usually reaching the sea. Water covers 71% of the Earth's surface, mostly in seas and oceans. Small portions of water occur as groundwater (1.7%), in the glaciers and the ice caps of Antarctica and Greenland (1.7%), and in the air as vapor, clouds (formed of ice and liquid water suspended in air), and precipitation (0.001%)[1].

Fresh water is any naturally occurring water except seawater and brackish water. Fresh water includes water in ice sheets, ice caps, glaciers, icebergs, bogs, ponds, lakes, rivers, streams, and even underground water called groundwater. Fresh water is generally characterized by having low concentrations of dissolved salts and other total dissolved solids.

Figure 1.shows availability fresh water and its form,Fresh water is not the same as potable water (or drinking water). Much of the earth's fresh water (on the surface and groundwater) is unsuitable for drinking without some

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treatment. Fresh water can easily become polluted by human activities or due to naturally occurring processes, such as erosion [1].

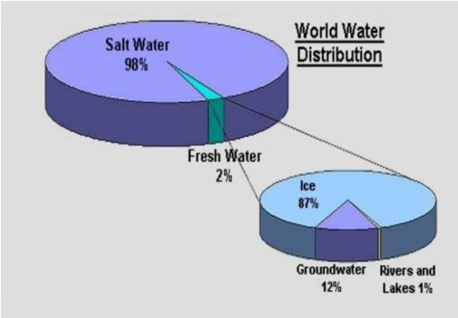

Fig. 1. Availability of fresh water and it's form

1.2 Dependence on fresh water

Freshwater makes up a very small fraction of all water on the planet. While nearly 70 percent of the world is covered by water, only 2.5 percent of it is fresh. The rest is saline and ocean-based. Even then, just 1 percent of our freshwater is easily accessible, with much of it trapped in glaciers and snowfields.

In essence, only 0.007 percent of the planet's water is available to fuel and feed its 6.8 billion people. Due to geography, climate, engineering, regulation, and competition for resources, some regions seem relatively flush with freshwater, while others face drought and debilitating pollution. In much of the developing world, clean water is either hard to come by or a commodity that requires laborious work or significant currency to obtain.

1.3 Desalination of saline water

Ensuring access to clean, fresh water is among the major problems faced by the world's growing population. As global water resources dwindle, the abundance of available seawater becomes an obvious option to fulfil water requirements through desalination.

Desalination plants have evolved rapidly during the last two decades to extract fresh water from the sea. Currently, approximately 150 countries rely on desalination to meet their fresh water requirements. Globally, around 80 million m3 of potable water is being produced daily by more than 17,000 desalination plants and of these, 50% are utilizing sea water as the source.

While most countries in the Middle East are rich in fossil energy resources, water is a rare commodity in the region so the water stress at these regions are extremely high and desalination is the only to get sufficient potable water for the growing population.

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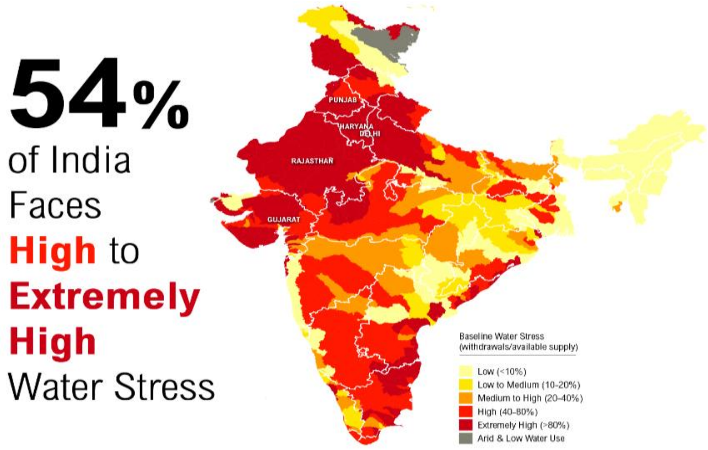

Fig.2 Water stress in India

Figure 2 shows water stress in india,According to the world health institute 54% of India faces High to Extremely High-water stressalmost 600 million people are at higher risk of surface-water supply disruptions.[2]

Although oceans and seas contain about 97% of Earth's water, currently only a fraction of a percent of the world's potable water supply comes from desalinated salt water. In order to increase our use of salt water, desalination techniques must become more energy-efficient and less expensive to be sustainable.

II. CONCEPT OF DESALINATION USING GRAPHENE OXIDE

New technologies are constantly being sought to lower the cost and footprint of processes that make use of water resources, as potable water (as well as water for agriculture and industry) are always in desperate demand. Much research is focused on graphene for different water treatment uses, and nanotechnology also has great potential for elimination of bacteria and other contaminants.

Among graphene's Most of remarkable traits, its hydrophobia is probably one of the traits most useful for water treatment. Graphene naturally repels water, but when narrow pores are made in it, rapid water permeation is allowed. This sparked ideas regarding the use of graphene for water filtration and desalination, especially once the technology for making these micro-pores has been achieved.

Graphene sheets are studied as a method of water filtration, because they are able to let water molecules pass but block the passage of contaminants and substances. Graphene's small weight and size can contribute to making a lightweight, energy-efficient and environmentally friendly generation of water filters and desalinators.

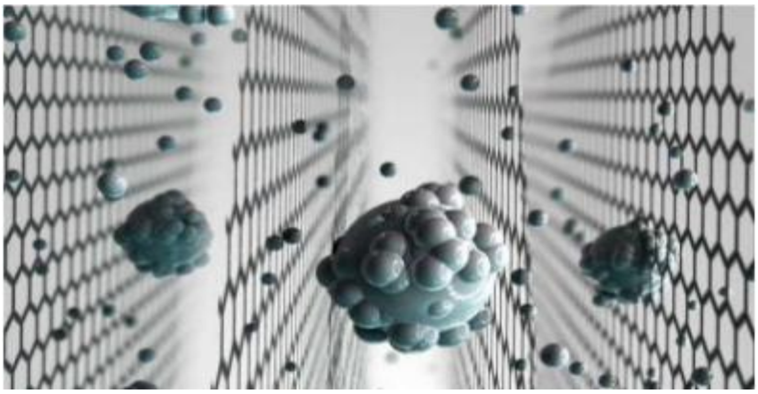

Fig.3. Shell of water molecule around the dissolved salt molecule

Figure 3 shows shell of water molecule around the dissolved salt molecule,It has been discovered that thin membranes made from graphene oxide are impermeable to all gases and vapours, besides water, and further research revealed that an accurate mesh can be made to allow ultrafast separation of atomic species that are very similar in size - enabling super-efficient filtering. This opens the door to the possibility of using seawater as a drinking water resource, in a fast and relatively simple way.

When the common salts are dissolved in water, they form a shell of water molecules around the salt molecules. This allows the tiny capillaries of the graphene oxide membranes to block the salt from flowing along with the water. Water molecules are able to pass through the membrane barrier and flow anomalously fast which is ideal for application of these membranes for desalination.

2.1 Machining process of selective holes on graphene

Researchers have devised a way of making tiny holes of controllable size in sheets of graphene, a development that could lead to ultrathin filters for improved desalination or water purification.It would be impossible to create Nano scale holes using traditional machining, by using Non-Traditional machining process viz. Chemical machining we can create sub nanoscale pores in a sheet of the one-atom-thick material, Making these minuscule holes in graphene a hexagonal array of carbon atoms, like atomic-scale chicken wire occurs in a two-stage process. First, the graphene is bombarded with gallium ions, which disrupt the carbon bonds. Then, the graphene is etched with an oxidizing solution that reacts strongly with the disrupted bonds producing a hole at each spot where the gallium ions struck. By controlling how long the graphene sheet is left in the oxidizing solution, we can control the average size of the pores.

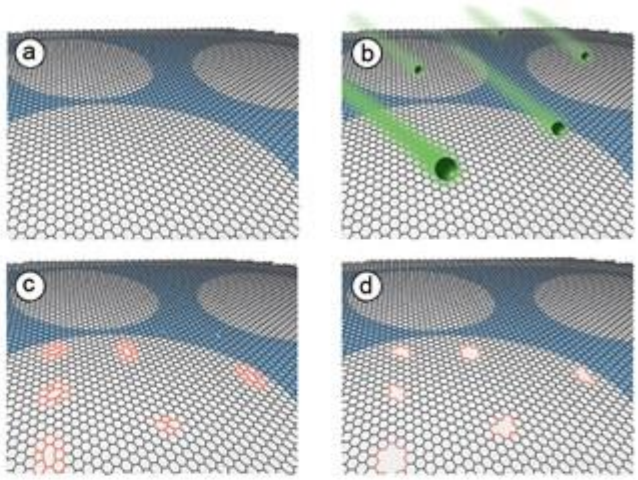

Fig.4. Process of creating selective membrane

Figure 4 shows process of creating selective membrane, With this technique, we will be able to control the filtration properties of a single, centimetre-sized sheet of graphene: Without etching, no salt flowed through the defects formed by gallium ions. With just a little etching, the membranes started allowing positive salt ions to flow through. With further etching, the membranes allowed both positive and negative salt ions to flow through, but blocked the flow of larger organic molecules. With even more etching, the pores were large enough to allow everything to go through. Scaling up the process to produce useful sheets of the permeable graphene, while maintaining control over the pore sizes, will require further research.

2.3 Chemical reactive of carbon atom in graphene sieve

The carbon atoms at the pore edge would be quite reactive without passivation, in one way or another under realistic experimental conditions they will likely have some form of chemical functionalization, this can be controlled to some extent, so we wanted to explore the two limits of hydrophobic vs. hydrophilic edge chemistries. If we had no functional groups (just bare carbon) then within a short time water molecule would dissociate at the pore edge and likely either hydrogenate or hydroxylate those carbons.

When compared the two chemistries, along with different pore sizes, of nanoporous graphene in their simulations by running saltwater with a salinity of 72 g/L over the membranes, this is about twice the salinity of average seawater (about 35 g/L).[5]

It was found that, although the largest nanopores could filter water at the highest rate, large nanopores allowed some salt ions to pass through. The simulations identified an intermediate range of nanopore diameters where the nanopores were large enough to allow the passage of water molecules but small enough to restrict salt ions.

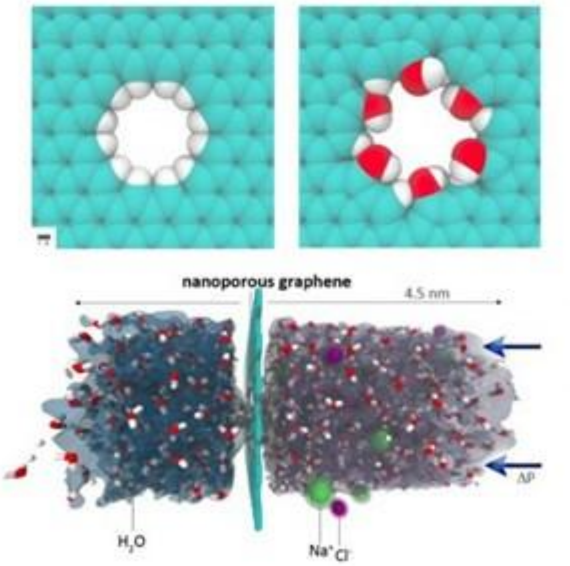

Fig. 5. Hydrogenated and (top right) hydroxylated graphene pores. (Bottom) Side view of the simulated nanoporous graphene filtering salt ions and producing potable water.

Figure 5 shows Hydrogenated and (top right) hydroxylatedgraphene pores. (Bottom) Side view of the simulated nanoporousgraphene filtering salt ions and producing potable water,The simulations also showed that the hydroxylated graphene significantly enhances the water permeability, which the scientists attribute to the hydrophilic nature of the hydroxyl groups. Since, in contrast, the hydrogenated pores are hydrophobic, water molecules can flow through only when in a limited number of highly ordered configurations. But hydrophilic groups allow watermolecules to have a greater number of hydrogen-bonding configurations inside the pores, and this lack of restrictions increases the water flux.

Overall, the results show that nanoporous graphene can theoretically outperform RO membranes in terms of water permeability, which is expressed in litres of output per square centimetre of membrane per day and per unit of applied pressure. Whereas high-flux RO has a water permeability of a few tenths, the simulations showed that nanoporous graphene's water permeability ranged from 39 to 66 for pore configurations that exhibited full salt rejection (23.1 Å^2 hydrogenated pores and 16.3 Å^2 hydroxylated pores). Graphene with the largest hydroxylated pores reached 129, but allowed some passage of salt ions. [9]

The scientists explain that there are two main challenges facing the use of nanoporous graphene for desalination purposes. One is achieving a narrow pore size distribution, although rapid experimental progress in synthesizing highly ordered porous graphene suggests that this may soon be feasible. The other challenge is mechanical stability under applied pressure, which could be achieved using a thin-film support layer such as that used in RO materials.

III.GRAPHENE OXIDE NANOSHEETS SORBENTS FOR HEAVY METAL ION POLLUTION MANAGEMENT

Heavy metal pollution due to the indiscriminate disposal of wastewater is a worldwide environment concern. Wastewaters from many industries such as metallurgical, mining, chemical manufacturing, and battery manufacturing industries contain many kinds of toxic heavy metal ions. Cadmium is among the toxic metals found in some surface and subsurface waters.

The increased use of Co(II) in nuclear power plants and in many industries has resulted in Co(II) findings its way to the environment. In high doses it causes bone defects, diarrhoea, low blood pressure, lung irritations and paralysis, and may also cause mutations (genetic changes) in living cells. Thereby, it is necessary to eliminate the toxic heavy metal ions from wastewater before it is released into the environment. Traditional techniques for the elimination of heavy metal ions include precipitation, membrane filtration, sorption, and ion exchange, etc.

Unlike carbon nanotubes, which require special oxidation processes to introduce hydrophilic groups to improve metal ion sorption, the preparation of graphene oxide nano sheets from graphite using Hummers method introduces many oxygen-containing functional groups such as -COOH, -CdO, and -OH, on the surfaces of graphene oxide nanosheets. These functional groups are essential for the high sorption of heavy metal ions. Graphene oxides, which are considered as the oxidized graphene, contain oxygen-containing functional groups on the surfaces. Considering the oxygen-containing functional groups on the graphene oxide surfaces and high surface area the graphene oxide nanosheets should have high sorption capacity in the pre-concentration of heavy metal ions from large volumes of aqueous solutions.

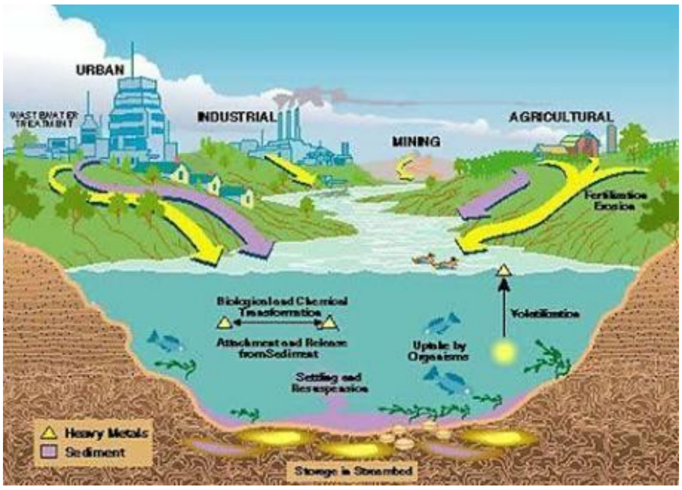

Fig.6. Heavy metal ion pollution due to human activities

Figure 6 shows Heavy metal ion pollution due to human activities,Used as sorbents for the removal of Cd(II) and Co(II) ions from large volumes of aqueous solutions. The effects of pH, ionic strength, and humic acid on Cd(II) and Co(II) sorption were investigated. The results indicated that Cd(II) and Co(II) sorption on graphene oxide nanosheets was strongly dependent on pH and weakly dependent on ionic strength. The abundant oxygen-containing functional groups on the surfaces of graphene oxide Nanosheets played a important role on Cd(II) and Co(II) sorption. The presence of humic acid reduced Cd(II) and Co(II) sorption on graphene oxide nanosheets at pH < 8.The graphene oxide nanosheets will be most suitablematerials in heavy metal ion pollution clean-up if they are synthesized in large scale and at low price in near future. [6]

However, the application of graphene oxide nanosheets as sorbents in the removal of heavy metal ions from aqueous solution is still scarce, especially in the presence of humic substances, which present widely in the natural environment, and have strong complexation ability with metal ions because of their abundant oxygen-containing functional groups. It is therefore important to study the sorption behaviours of metal ions on graphene oxide nano sheets in the presence of human substance.

IV.CONCLUSION

Water treatment and Heavy Metal-Pollution control. Water treatment using Graphene-Oxide is more efficient and compact when compared to most of the methods or materials we use today.

Due to its unique physicochemical properties. Herein, few-layered graphene oxide nanosheets were synthesized from graphite using the modified Hummers method, and were used as sorbents for the removal of Cd(II) and Co(II) ions from large volumes of aqueous solutions.

However, the application of graphene oxide nanosheets as sorbents in the removal of heavy metal ions from aqueous solution is still scarce, especially in the presence of humic substances, which present widely in the natural environment, and have strong complexation ability with metal ions because of their abundant oxygen-containing functional groups. It is therefore important to study the sorption behaviours of metal ions on graphene oxide nano sheets in the presence of human substance.

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Bibliographical Note's

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