

Removal of Arsenic from Ground Water by Electrocoagulation Effluent Treatment Process using Low Cost Adsorbents

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Abstract - Water pollution due to the disposal of heavy metals continues to be a great concern world-wide. As a result, the treatment of dirty industrial wastewater remains a topic of global concern because wastewater collected from municipalities, communities and industries must eventually be returned to receiving water source [1]. In order to remove this toxic heavy metals many techniques are used all over the world. In these pile of techniques **ETP (EFFLUENT TREATMENT PROCESS)** that uses **ELECTROCOAGULATION SYSTEM METHOD** along with **LOW COST ADSORBENTS** has drew serious attention. Low cost adsorbents are preferred over others due to their low cost, ease of application and eco-friendliness etc. The various low cost adsorbents are green shell, peanut husk, zeolites and Fly ash etc. This review paper acknowledges comparison between adsorbent made up from green coconut shell that is used in combination with ETP and ECOAG PROCESS with ferric hydroxide that is also used as an adsorbent to get rid of toxic heavy metals such as arsenic from ground water.

Key Words: Water pollution, Water treatment, Heavy metal, Arsenic, E-coagulation, ETP, Low-cost Adsorbents, Green coconut shell, Iron hydroxide.

1. INTRODUCTION

We know, Arsenic is one of the toxic elements. It affects the ground water which arises to many health diseases for humans and animals. There are many ways of detoxing water where in Electrocoagulation, Membrane Technology, Effluent Treatment Process (ETP), etc. works for removing Arsenic from ground water.

1.1 Water Contamination

As commercial global has grown, environmental demanding situations have additionally increased. A known form of pollutants the arena is presently suffering with is water pollutants. Water pollutants may be as a result of a selection of things consisting of agriculture, sewage and wastewater, oil pollutants and radioactive substances. Wastewater, specifically which discarded through industries, can comprise an extensive variety of heavy metals. The ranges of heavy metals infection in water which incorporates Pb, As, Cd, Hg, Cr, Ni etc. in severa water reassets as ground, ground and tap water etc. A form of heavy metals, some of them are potentially toxic and are transferred to the surrounding

environment thru via severa pathways. Heavy metal toxicity has validated to be a main risk and there are various health risks associated with it. The toxic effects of these metals, regardless of the truth that they do now not have any natural role, their toxic effects are despite the fact that risky for the human body and its proper functioning. [2][3]

1.2 Arsenic

Arsenic is a natural semi steel chemical that is located anywhere within side the worldwide in numerous water bodies. Arsenic has 185pm molecular size. The allowed interest of arsenic in drinking- water is 10 micrograms consistent with litre [4]. Arsenic, a well-known carcinogen, is regarded as one of the world-wide's most risky chemicals [5]. Arsenicosis, a now no longer unusual place name commonly used for As related health problems which consist of pores and pores and skin disorders, pores and pores and skin cancers, internal cancers (bladder, kidney, and lung), ailments of the blood vessels of the legs and feet, possibly diabetes, multiplied blood pressure, and reproductive disorders[6][7]. Current techniques to remove arsenic embody precipitation, such as lime or coagulants to water, the use of membranes to clean out it out, or the use of an ion ex-trade process [8]. The most inexperienced and used method for removal of arsenic are MEMBRANE TECHNOLOGIES, COAGULATION, ADSORBPTION [9]. There are subtypes for membrane technology and adsorption.

2. METHODS TO REMOVE ARSENIC

Membrane technology is divided into four types, those are Microfiltration, **Ultrafiltration**, Nano filtration and **Reverse Osmosis**. In Adsorption, we have Activated Alumina, **Iron based sorbents**, Zero- valent iron, Indigeneous filters, miscellaneous sorbents, metal organic framework. Electro-coagulation is a type of an advanced oxidation reaction. In this review paper we shall be discuss on electrocoagulation and low cost adsorbents [10].

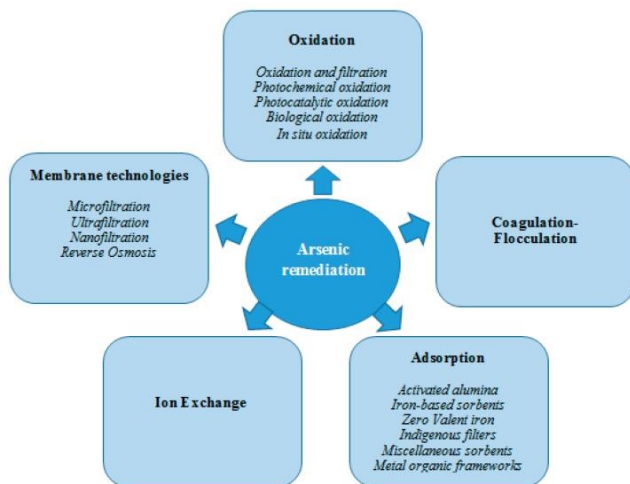


Fig -1: Tree diagram for Arsenic Removal processes [9]

3. PROCESS OF REMOVING ARSENIC

3.1 Electro- coagulation

Electro coagulation (EC) is a manner used for waste water treatment, wash water treatment, industrially processed water, and medical treatment. Electro coagulation is a swiftly growing place of wastewater treatment due to its ability to eliminate contaminants which can be usually harder to eliminate through manner of way of filtration or chemical treatment systems, which incorporates emulsified oil, ordinary petroleum hydrocarbons, refractory organics, suspended solids, and heavy metals [11]. There are many producers of electro coagulation devices available ranging in complexity from a clean anode and cathode to lots more complex devices with control over electrode potentials, passivation, anode consumption etc. It is essential to be conscious that electro coagulation era cannot eliminate infinitely soluble matter. Therefore, ions with molecular weights smaller than Ca^{+2} or Mg^{+2} cannot be dissociated from the aqueous medium. [12]

Whole Electro-coagulation manner incorporates of four-stages:-

- a) Effluent Tank/ septic tank
- b) Pump
- c) E-coagulation reactor
- d) Settling Tank

(a) Effluent Tank

The septic tank was one of the first treatment devices invented. They are intended to hold wastewater at low velocity, under anaerobic conditions for a minimum detention time of 36 hours. During this period, a high removal of settled solids was achieved. These solids

decompose within side the backside of the tank with the formation of fuel line, which entrained within side the solids reasons them to upward thrust thru the wastewater to the floor and lie as a scum layer till the fuel line has escaped, and then the solids settle again. Annual inspection is to be held to put off sludge and for cleansing the effluent tank/septic tanks [13].

(b) Pump

A pump is a device that moves fluids (liquids or gases), or sometimes slurries by mechanical action, converting electrical energy into hydraulic energy. Pumps are classified into three major groups based on the method they used to move the fluid: direct lift, displacement, and gravity pumps [14]

There are basically three types of pumps:-

- positive-displacement
- centrifugal
- Axial- flow pumps.

There are various other types in positive-displacement those are:- Rotary lobe pump, Progressive cavity pump, Rotary gear pump, Piston pump, Diaphragm pump, Screw pump, Gear pump, hydraulic pump[15]

(c) E- coagulation Reactor

The E- coagulation reactor is made up of non- corrosive fiberglass with proprietary designed parallel plates of electrodes. When the DC current from the power supply flows through the electrode, metal ions are released form anode into the water (generating the ion Al^{3+} if the anode is aluminum and Fe^{3+} if it is steel) simultaneously on the cathode hydroxyl group and hydrogen are produced. This is followed by ionization, destabilization, oxido- reduction, electrolysis, free radical formation, electromagnetic field formation, and emulsion breaking and separation [16]

(d) Settling Tank

Sedimentation tank, moreover referred to as a settling tank or clarifier, is a part of a contemporary-day device of water supply or wastewater treatment. A sedimentation tank permits suspended particles to settle out of water or wastewater as it passes slowly via the tank, thereby imparting some degree of purification. A layer of collected solids, referred to as sludge, office work at the bottom of the tank and is periodically removed. In drinking-water treatment, coagulants are added to the water preceding to sedimentation so you can facilitate the settling process, this is then observed via filtration and exclusive treatment steps. To decorate purification overall performance primary sedimentation want to be observed via. Secondary treatment (e.g, trickling clean out or activated sludge) to growth purification efficiencies. Sedimentation is commonly

preceded via treatment with bar presentations and grit chambers to remove large objects and coarse solids [16]

- Horizontal flow tanks. ...
- Radial flow tanks. ...
- Inclined settling. ...
- Ballasted sedimentation. ...
- Floc blanket sedimentation.

3.2 Electro- coagulation in combination with Effluent Treatment Process (ETP)

As Electro-coagulation does not remove infinitely soluble matter. Therefore, ions with molecular weights smaller than Ca^{+2} or Mg^{+2} cannot be dissociated from the aqueous medium. So to remove all the metal toxicities and to get clean drinking water **Effluent treatment process (ETP)** was introduced.

ETP includes processes like Activated charcoal treatment (adsorption)

Reverse Osmosis (RO) Ozonization (Chemical oxidation) Ultra Filtration (UF) etc. ETP has membrane technology as its core.

Advantages of E-coagulation and Effluent Treatment Process:-

- Less maintenance and minimal to zero chemicals.
- Unnecessary water usage during the processing is eliminated and makes your industry self-sustainable.
- Helps reduce the contamination of natural water bodies
- It costs less and create lesser sludge with less bound water.

3.3 Membrane Technology

Membrane era has developed to be a dignified separation era during the last decennia. The foremost pressure of membrane era is the reality that it really works without the addition of chemicals, with an exceedingly low strength use and smooth and well- organized manner. Membranes are used increasingly frequently for the introduction of manner water from groundwater, floor water or wastewater. The membrane separation manner is primarily based totally at the presence of semi permeable membranes.

The precept is pretty simple: the membrane acts as a completely particular clear out a good way to permit water float via, even as it catches suspended solids and different materials. Membranes occupy area thru a particular separation wall. Certain materials can by skip via the membrane, even as different are trapped. Membrane filtration may be hired as an opportunity to flocculation, sediment purification procedures, adsorption (sand filters

and lively carbon filters, ion exchangers), extraction and distillation. [18][19][20]

Membrane filtration is assessed as micro and ultra- filtration on the only hand and Nano filtration and Reverse Osmosis (RO or hyper filtration) on the opposite hand. When the usage of membrane filtration to get rid of large particles, micro filtration and ultra-filtration are applied. Because of the open man or woman of the membranes the productiveness is excessive even as the stress variations are low. When salts want to be eliminated from water, Nano filtration and Reverse Osmosis are applied. Nano filtration and RO membranes do now no longer paintings in line with the precept of pores; separation takes region through diffusion via the membrane. The stress this is required to carry out Nano filtration and Reverse Osmosis is a great deal better than the stress required for micro and ultra- filtration, even as productiveness is a great deal lower. [18][19][20]

3.4 Effluent Treatment Process (ETP)

The precept of operation of ETP is Physio-Chemical remedy observed through Polishing Treatments which include Sand Filtration, Activated Charcoal remedy (Adsorption), Ozonization (Chemical Oxidation), Ultra Filtration (UF), Reverse Osmosis (RO) and evaporation (If required). ETP are used for the elimination of excessive quantities of natural compounds, debris, dirt, grit, pollution, poisonous, non-poisonous substances and polymers etc. from business effluent. Industrial wastewater remedy refers back to the strategies which can be applied to deal with wastewater this is created through industries as an unwanted through-product. After remedy, the dealt with business wastewater can be reused or discharged right into a sanitary sewer or to a floor water within side the environment [21] [22].

Whole ETP contains of 4 stages:-

- Sand Filter
- Filter Press
- Ultra Filter
- RO system

(a) Sand Filter

Sand filtration is one of the maximum well- acknowledged wastewater remedy methods. If well designed, built, operated, and maintained, a sand clear out produces a completely excessive fine effluent. Sand filters are beds of granular material, or sand, tired from under in order that pretreated wastewater may be treated, accumulated, and dispensed to the very last remedy and dispersal gadget. They are generally used to shine effluent from septic tanks or different remedy strategies earlier than miles dispensed at

the land. All on-web website online structures are “no-discharge,” this means that the wastewater should stay within side the gadget and now no longer go away the property. The effluent can't input floor water, streams, ditches, or every other water resources. After the filtrate is accumulated via way of means of the sand clear out underdrains miles then disposed of via way of means of a soil absorption gadget [23].

(b) Filter Press

Filter press is one of the oldest and most reliable pieces of dewatering equipment. It's used for wastewater treatment across a range of industries and applications. A filter press separates particles from liquids while also eliminating contaminants, and suspended solids from industrial wastewater. This enables plant managers to conveniently handle and dispose of waste while returning clean water to their systems.

Filter presses are used to separate liquids and solids. Specifically, the filter press separates the liquids and solids using pressure filtration across a filter media. Afterward, the slurry is pumped into the filter press and then dewatered under pressure. [24]

What are the Four Main Components of a Filter Press?

- Frame
- Filter Plates
- Manifold (piping and valves)
- Filter Cloth (This is key for optimizing filter press operations.)

Basically, the filter press design is based on the dewatering volume and type of slurry. [24]

(c) Ultra Filter

In wastewater treatment, ultrafiltration (UF) devices are used to recycle and reuse water that contains virtually no physical solids. Ultrafiltration definition, applications and industries using these process units are covered below. Ultrafiltration (UF) is a variety of membrane filtration in which forces like pressure or concentration gradients lead to a separation through a semipermeable membrane. Suspended solids and solutes of high molecular weight are retained in the so-called retentate. When treating water with high suspended solids, UF is often integrated into the process, using primary (screening, flotation and filtration) and some secondary treatments as pre-treatment stages. [25]

Ultrafiltration processes are preferred over traditional treatment methods for the following reasons:

- No chemicals required (aside from cleaning)
- Constant product quality regardless of feed quality
- Compact plant size

- Capable of exceeding regulatory standards of water quality, achieving 90-100% pathogen removal.

Pore size of Ultra Filtration membrane ranges from 0.005-0.1µm.

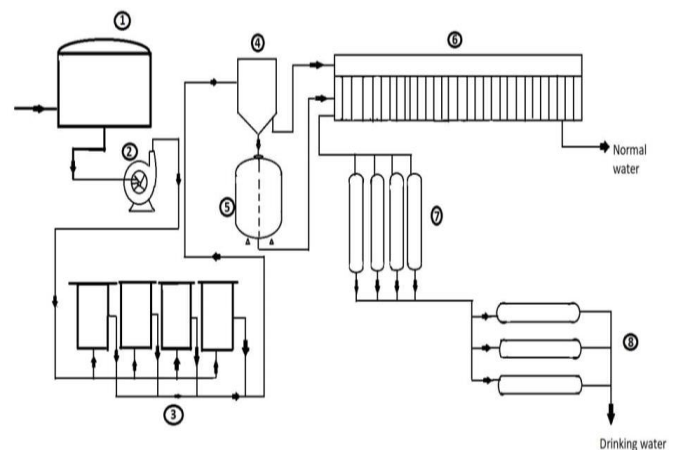
(d) Reverse Osmosis (RO)

Reverse Osmosis is a water purification technique that makes use of strain and a semi-permeable membrane to put off dissolved solids. The RO water is saved in a maintaining tank. If the RO water wishes greater purification, a Deionization System will lessen the conductivity of the RO water. [26]

Industrial RO Applications:-

- Metallic completing and plating operations
- Published circuit board and semiconductor manufacturing
- Electroplating processes
- Automobile manufacturing

Pore size of RO ranges from **0.0001-0.001 nm**



1. Effluent Tank
2. Pump
3. Electro- coagulation Reactors
4. Settling Tank
5. Sand Filter
6. Filter Press
7. Ultra Filtration (UF)
8. Reverse Osmosis (RO)

Fig -2: Flow sheet of the Technology

3.4 Low- Cost Adsorbents

An adsorbent is an insoluble material coated by liquid on the surface, including capillaries and pores. A material is said to be adsorbent when it has the capacity to contain a definite amount of liquid in small chambers similar to a sponge. Adsorbents play a vital role in chemical absorption, which takes place when a certain substance is trapped on a material's surface. Properties of a suitable adsorbent are high selectivity, high absorption capacity, long life, and low cost. Different adsorbent possesses various properties divers as its active surface, pore diameter, quality of pore distribution, and surface functional group. Pore sizes of porous materials are classified generally into three ranges, according to the IUPAC

- *macro pores*: "diameter" > 50 nm,
- *meso pores* (also known as transitional pores): $2 \text{ nm} \leq \text{"diameters"} \leq 50 \text{ nm}$
- *Micro pores*: "diameters" < 2 nm.

Low-cost adsorbents refer to those materials, which are found abundantly in the environment or are byproducts or wastes from industries. Moreover, adsorbents are known as low costs if they have reduced processing requirements. Previous adsorption works concentrated on plant wastes such as, the Peat and coconut fiber, carrots, rice husks, Cane papyrus, modified coconut husk, rice bran, and others, which can be utilized each on the normal compose or change several alterations physical or chemical. Converting these materials into adsorbents is an effective way of reducing the costs of waste disposal and for providing alternate treatments for replacing the commercially activated carbons. [27]

(a) Green Coconut Shell:-

Green coconut shell is extensively used as adsorbent in waste water remedy as miles without difficulty to be had everywhere

Pre-remedy of the adsorbent:-

Green coconut shells have been furnished through Embrapa Tropical Agroindustry, CE, Brazil (EMBRAPA/CE). The adsorbent turned into dealt with NaOH 0.1 mol L⁻¹ for three h after which washed with deionized water, buffer solution (pH 5.0) and dried at 50 °C. This cloth turned into cooled at room temperature after which sieved to attain preferred particle size (0246–0074 mm) [28]

(b) Iron Oxy- Hydroxides:-

Arsenic adsorption the usage of iron compounds, zero-valent iron, Iron- primarily based totally bimetal oxides, iron-doped composite adsorbents are seriously reviewed and their adsorption efficiencies are compared. Besides the adsorption capacities, the traits of adsorption tactics, which include

thermodynamics, kinetics and mass switch mechanisms also are examined. The precise binding among arsenic and iron turned into deeply investigated via way of means of numerous spectral technologies. Moreover, a few iron-primarily based totally adsorbents are magnetic, making an allowance for a smooth separation of the saturated substances from water in an outside magnetic field.

Many distinctive substances had been stated to have a very good affinity in the direction of arsenic, however iron oxy-hydroxides are the maximum extensively studied due to their smooth accessibility. The generally used iron oxy-hydroxides such as, akagan'eite (b-FeOOH), goethite (a-FeOOH), lepidocrocite (g-FeOOH), ferrihydrites (Fe₁₀O₁₄(OH)₂), inexperienced rusts may be chemically synthesized via way of means of the precipitation of Fe(III) or Fe(II) salts via the hydrolysis and oxidation tactics The solid As(III) oxidation country within side the darkish is steadily converted to As(V) on ferrihydrites in presence of mild at pH 5. At the equal time, Fe(III) ions have been decreased to Fe(II) species at some point of the As(III) oxidation,⁵⁶ It turned into located the adsorption rate (12.4105 M s¹ m²) on goethite turned into appreciably quicker than that of ferrihydrites (6.seventy three one hundred and five M s¹ m²) at pH 5.fifty seven The comparable photochemical response turned into additionally located for As(III) adsorption on goethite within side the presence of dissolved oxygen Laterite, a herbal iron oxide mineral containing 91% of goethite, is some other promising and cost-powerful fabric for arsenic adsorption.⁵⁹ The precise adsorption of arsenic is proven via way of means of a sturdy proof of the shift of isoelectric point.[29]

4. CONCLUSIONS:-

In this review paper we focused on removal of Arsenic from ground water by E-coagulation Effluent treatment process using Low cost adsorbents. There were many other processes but E-coagulation and ETP were most efficient. E-coagulation treatment uses electrode s to remove contaminants where-as ETP (Effluent Treatment Process) has its core into membrane technology. As E-coagulation process cannot remove all the infinitely small contaminants and heavy metals. There was a need to combine E-coagulation process with ETP. As this combination of two processes was not enough to remove all the contaminants Low cost adsorbents were introduced.

There were two adsorbents studied in this review paper those are Adsorbent from green coconut shell (natural adsorbent) and the second was Iron oxy hydroxide(chemical adsorbent).low cost adsorbents Adsorb most of the contaminants and heavy metals onto its surface. Due to these three processes the chances of removal of maximum arsenic are very high and at the end the treated water goes through RO where it's again treated to be drinkable.

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