IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Various methods of treatment for water

Uddipta Sarma[a*], Utkarsh Dixit[a]

M.Sc Scholar, Research Scholar

[a]Surface Science Laboratory, Department of Chemistry, School of Physical and Decision Science Babasaheb Bhimrao Ambedkar University (A Central University) Lucknow-226025

Uttar Pradesh (India)

Abstract: Wastewater treatment is a process used to remove contaminants from wastewater or sewage and convert it into an effluent that can be returned to the water cycle with an acceptable impact on the environment, or reused for various purposes (called water reclamation). Pollutants in wastewater are removed, converted or broken down during the treatment process. In this paper, various available methods for the treatment of water, their working principle, advantages and disadvantages are discussed in detail. The various methods discussed are precipitation method, Flocculation-Coagulation, Electro-flocculation, Electro-flotation, Electrochemical Coagulation, Biological Degradation, Chemical Oxidation (Ozonation, Hydrogen Peroxide), Reverse Osmosis and adsorption. Out of all the methods discussed adsorption is found to be best because of its low cost and effectiveness but it also has certain disadvantages which are discussed.

Key-Words: Wastewater treatment, contaminants, pollutants

Precipitation method

Working principle: Precipitation is a technique used to separate a mixture based on the solubility of its components. The solubility of a compound depends on the ionic strength of the solution, its pH, and temperature [1]. Manipulation of these factors can cause a compound to become an insoluble solid, and fall out of solution [2].

Advantage:

1. It can be used to obtain good results with several substances that are difficult to remove with other techniques.
2. This technique is that very specific components can be removed, while not removing other substances; thus, there is a high degree of selectivity.

Disadvantage:

1. A large quantity of reagent is generally needed, which is often very expensive.
2. A large quantity of silt is produced in this technique.
3. Few problems are encountered if the silt can be precipitated as a useful by-product; if, for example, the silt contains heavy metals, it will be regarded as dangerous waste and will be accompanied by high processing costs.

Flocculation-coagulation

Working principle: Coagulation-flocculation is a chemical water treatment technique typically applied before sedimentation and filtration to enhance the ability of a treatment process to remove particles [3]. Coagulation is a process used to neutralise charges and form a gelatinous mass to trap (or bridge) particles thus forming a mass large enough to settle or be trapped in the filter [4]. Flocculation is gentle stirring or agitation to encourage the particles thus forming to agglomerate into masses large enough to settle or be filtered from the solution [5].

Advantages:

1. Simplicity and cost-effectiveness
2. Separates many kinds of particles from the water
3. Enhances filtration process
4. Uses abundant and low-cost chemicals

Disadvantages:

1. The input of chemicals required
2. Qualified personnel required for design (e.g. construction of chambers and dosage of chemicals) and system maintenance
3. Transfer of toxic compounds into solid phase and formation of sludge that has to be treated subsequently
4. Relatively time-consuming process

Electro-flocculation

Working Principle: Electro-flocculation generally refers to the electrolytic addition of the metal ions, Al and Fe at the anode and the formation of gas bubbles (H2) at the cathode [6]. The gas bubbles capture the pollutants to which the metal ions have attached and float most of them to the water surface as a stable floc [7]. Only a small percentage of the floc sink to the bottom. But generally, the flocculation process is enhanced for 10 to 15 %, when instead of chemical flocculation electro-flocculation techniques have been used [8]. Electro-flocculation is a combination of the processes of electro-flotation and electron precipitation [9]. These two processes occur at the same time in the electro-flocculation tank. The insoluble product, separated from the liquid, is called a precipitate. Electro-precipitation is a flocculation process where the flocculating agent is the ion of metal that is precipitated from the anode [26]. The metal ions are released in the electrolyte and adsorb onto the surface of colloidal particles [10].

Advantages:

1. It can lead to better-quality effluent
2. Metals can be recovered from the solution
3. It only requires a low level of electrical current

Disadvantages:

1. Electrodes are impermanent
2. All of the following factors can affect the results of the process:

- Material and design of the electrode
- The gap between the two electrodes
- The electrodes' polarity
- The density of the current
- The conductivity of the wastewater
- The pH of the wastewater
- The size of the particles
- And other elements

3. Active fine-tuning is required

Electro-flotation

Working Principle: Electro- Flotation based on the introduction of gas bubbles as the transport medium [11]. Suspended particulate matter, being hydrophobic or conditioned to be so, is then attached to the bubbles and moves toward the water solution surface i.e., contrary to the direction of gravity [12].

Advantages:

1. A silent process that does not require a large amount of energy
2. The high removal efficiency of suspended solids
3. High COD abatement rate by native oxygen bubbles formed at the anode
4. Possible control of mass and size of bubble produced by simple adjustment of current density and possible use of solar energy as a power source

Disadvantages:

1. Separation efficiency depends strongly on bubble sizes
2. Filtration process for flocs

Electrochemical Coagulation

Working Principle: Electrocoagulation consists of pairs of metal sheets called electrodes, that are arranged in pairs of two—anodes and cathodes [13]. Using the principles of electrochemistry, the cathode is oxidized (loses electrons), while the water is reduced (gains electrons), thereby making the wastewater better treated [14].

Advantages:

1. Efficient technology for the recovery/recycling of valuable metals.
2. An interesting method for the recovery of gold and silver from rinse baths.
3. Adaptation to different pollutant loads and different flow rates.
4. Increases biodegradability
5. More effective and rapid organic matter separation than in traditional coagulation
6. Economically feasible and very effective in removing suspended solids, dissolved metals, tannins and dyes (effluents from textile, catering, petroleum, municipal sewage, oil–water, emulsion, dyestuff, clay suspension, etc.)
7. Efficient elimination of SS, oils, greases, colour and metals
8. Widely used in the mining industries
9. Effective in the treatment of drinking water supplies for small- or medium-sized communities
10. Very effective treatment for the reduction, coagulation and separation of copper

Disadvantages:

1. The high initial cost of the equipment
2. Cost of the maintenance (sacrificial anodes, etc.)
3. Requires addition of chemicals (coagulants, salts)
4. Anode passivation and sludge deposition on the electrodes can inhibit the electrolytic process in continuous operation
5. Requires post-treatment to remove high concentrations of iron and aluminium ions
6. Formation of sludge (filtering problems)
7. Cost of sludge treatment

Biological Degradation

Working Principle: The microbial organisms transform the substance through metabolic or enzymatic processes. It is based on two processes: growth and metabolism [15]. In growth, an organic pollutant is used as the sole source of carbon and energy. This process results in a complete degradation (mineralization) of organic pollutants [16,25].

Advantages:

1. The application of microorganisms for the biodegradation of organic contaminants is simple and economically attractive.
2. A large number of species used in mixed cultures or pure cultures
3. Efficiently eliminates biodegradable organic matter, NH_3, NH_4^+, iron
4. Attenuates colour well
5. High removal of biochemical oxygen demand and suspended solids (BAS)
6. The decisive role of microbiological processes in the future technologies used for the removal of emergent contaminants from waters

Disadvantages:

1. Necessary to create an optimally favourable environment
2. Requires management and maintenance of the microorganisms and/or physicochemical pre-treatment (inefficient on non-degradable compounds or when toxic compounds are present)
3. Slow process (problems of kinetics)
4. Low biodegradability of certain molecules (dyes)
5. Poor decolourization
6. Possible sludge bulking and foaming
7. Generation of biological sludge and uncontrolled degradation products
8. The complexity of the microbiological mechanisms
9. The necessity to have a good knowledge of the enzymatic processes governing the decomposition of the substances

Chemical Oxidation (Ozonation, Hydrogen Peroxide)

Working Principle: Chemical oxidation is a process involving the transfer of electrons from an oxidizing reagent to the chemical species being oxidized [17]. In water and wastewater engineering, chemical oxidation serves the purpose of converting putrescible pollutant substances to innocuous or stabilized products [18].

Advantages:

1. Physiochemical process
2. Simple, rapid and efficient process
3. Generation of ozone *on-site* (no storage-associated dangers)
4. Quality of the outflow (effective destruction of the pollutants and efficient reduction in colour)
5. Good elimination of colour and odour (ozone)
6. Efficient treatment for cyanide and sulfide removal
7. Initiates and accelerates azo bond cleavage (hypochlorite treatment)
8. Increases biodegradability of the product
9. High throughput
10. No sludge production
11. Possibility of water recycle
12. Disinfection (bacteria and viruses)

Disadvantages:

1. Chemicals required
2. Production, transport and management of the oxidants (other than ozone)
3. Pre-treatment indispensable

4. Efficiency is highly influenced by the type of the adsorbent
5. A few dyes are more resistant to treatment and necessitate high ozone doses
6. Formation of (unknown) intermediates
7. Short lifetime
8. No diminution of chemical oxygen demand values or limited effect (ozone)
9. No effect on salinity (ozone)
10. Release of volatile compounds and aromatic amines (hypochlorite treatment)
11. Generates sludge

Reverse Osmosis

Working Principle: Reverse osmosis membrane separation is a method of water treatment in which sufficient pressure is applied against feedwater to force it through a semipermeable membrane and separate water molecules from other constituents within the water [19,24].

Advantages:

1. Wide range of commercial membranes available from several manufacturers.
2. A large number of applications and module configurations.
3. Small space requirement.
4. Simple, rapid and efficient, even at high concentrations.
5. Produces a high-quality-treated effluent.
6. No chemicals required.
7. Low solid waste generation
8. Eliminates all types of dyes, salts and mineral derivatives.
9. Efficient elimination of particles, suspended solids and microorganisms, volatile and non-volatile organics, dissolved inorganic matter and phenols, cyanide and zinc.

Disadvantages:

1. Investment costs are often too high for small and medium industries.
2. High energy requirements.
3. The design of membrane filtration systems can differ significantly.
4. High maintenance and operation costs.
5. Rapid membrane clogging (fouling with high concentrations).
6. Low throughput.
7. Limited flow rates.
8. Not interesting at low solute feed concentrations.
9. The choice of membrane is determined by the specific application (hardness reduction, particulate or total organic carbon removal, potable water production, etc.)

Adsorption

Working Principle: Adsorption is a process whereby a substance (adsorbate, or sorbate) is accumulated on the surface of a solid (adsorbent, or sorbent) [20]. The adsorbate can be in a gas or liquid phase [21]. The driving force for adsorption is unsaturated forces at the solid surface which can form bonds with the adsorbate [22,23].

Advantages:

1. Technologically simple (simple equipment) and adaptable to many treatment formats.
2. Wide range of commercial products
3. Wide variety of target contaminants (adsorption)
4. Highly effective process (adsorption) with fast kinetics
5. Excellent quality of the treated effluent
6. Global elimination but possibly selective depending on adsorbent
7. Excellent ability to separate a wide range of pollutants

Disadvantages:

1. Relatively high investment, Cost of materials (Activated charcoal)
2. Non-selective methods
3. Performance depends on the type of material
4. Requirement for several types of adsorbents
5. Chemical derivatization to improve their adsorption capacity
6. Rapid saturation and clogging of the reactors (regeneration costly)
7. Not efficient with certain types of dyestuffs and some metals
8. Elimination of the adsorbent (requires incineration, regeneration or replacement of the material)
9. Regeneration is expensive and results in the loss of material
10. Economically non-viable for certain industries (pulp and paper, textile, etc.)

Conclusion: This study evaluates the performance of different models based on their cost, working procedure, efficiency and regeneration. As in the adsorption method, the adsorbent is regenerated and can be used several times the adsorption, hence this method is found to be best for adsorption among all the available methods.

References:

1. Anjaneyulu Y, Sreedhara Chary N, Samuel Suman Raj D (2005) Decolourization of industrial efuents: available methods and emerging technologies—a review. Rev Environ Sci Bio/Technol 4:245–273. https://doi.org/10.1007/s11157-005-1246-z Barakat MA (2011)
2. New trends in removing heavy metals from industrial wastewater. Arab J Chem 4:361–377. https://doi. org/10.1016/j.arabjc.2010.07.019
3. Berefeld LD, Judkins JF, Weand BL (1982) Process chemistry for water and wastewater treatment. Prentice-Hall, New Jersey

4. Bratby J (ed) (2006) Coagulation and focculation in water and wastewater treatment. IWA Publishing, London, p 407
5. Chen G (2004) Electrochemical technologies in wastewater treat - ment. Sep Purif Technol 38:11–41. https://doi.org/10.1016/j. seppur.2003.10.006
6. Chuah TG, Jumasiah A, Azni I, Katayon S, Choong SYT (2005) Rice husk as a potentially low-cost biosorbent for heavy metal and dye removal: an overview. Desalination 175:305–316. https:// doi.org/10.1016/j.desal.2004.10.014
7. Cooney DO (1999) Adsorption design for wastewater treatment. Lewis Publishers, Boca Raton
8. Cox M, Négré P, Yurramendi L (2007) Industrial liquid efuents. INASMET Tecnalia, San Sebastian, p 283
9. Crini G (2005) Recent developments in polysaccharide-based materials used as adsorbents in wastewater treatment. Prog Polym Sci 30:38–70. https://doi.org/10.1016/j.progpolymsci.2004.11.002
10. Crini G (2006) Non-conventional low-cost adsorbents for dye removal. Bioresour Technol 97:1061–1085. https://doi.org/10.1016/j.biort ech.2005.05.001
11. Crini G, Badot PM (eds) (2007) Traitement et épuration des eaux industrielles polluées. PUFC, Besançon
12. Crini G, Badot PM (eds) (2010) Sorption processes and pollution. PUFC, Besançon
13. Crini G, Lichtfouse E (2018) Wastewater treatment: an overview, chapter 1. In: Crini G, Lichtfouse E (eds) Green adsorbents for pollutant removal—fundamentals and design, environmental chemistry for a sustainable world, vol 1. Springer, Berlin, pp 1–21. https:// doi.org/10.1007/978-3-319-92111-2_1. ISBN 978-3-319-92111-2
14. Forgacs E, Cserhati T, Oros G (2004) Removal of synthetic dyes from wastewaters: a review. Environ Int 30:953–971. https://doi. org/10.1016/j.envint.2004.02.001
15. Hai FI, Yamamoto K, Fukushi K (2007) Hybrid treatment systems for dye wastewater. Crit Rev Environ Sci Technol 37:315–377. https ://doi.org/10.1080/10643380601174723
16. Harvey PJ, Campanella BF, Castro PM, Harms H, Lichtfouse E, Schäfner AR, Smrcek S, Werck-Reichhart D (2002) Phytoremediation of polyaromatic hydrocarbons, anilines and phenols. Environ Sci Pollut Res Int 9:29–47
17. Henze M (ed) (2001) Wastewater treatment—biological and chemical processes. Springer, Berlin
18. Kentish SE, Stevens GW (2001) Innovations in separations technology for the recycling and re-use of liquid waste streams. Chem Eng J 84:149–159
19. Khalaf MN (ed) (2016) Green polymers and environmental pollution control. CRC Press, Oakville
20. Liu DHF, Liptak BG (eds) (2000) Wastewater treatment. CRC Press, Boca Raton
21. Mohan D, Pittman CU (2007) Arsenic removal from waste/wastewater using adsorbents—a critical review. J Hazard Mater 142:1–53. https://doi.org/10.1016/j.jhazmat.2007.01.006
22. Morin-Crini N, Crini G (eds) (2017) Eaux industrielles contaminées. PUFC, Besançon
23. Parsons S (ed) (2004) Advanced oxidation process for water and wastewater treatment. IWA Publishing, London
24. Pokhrel D, Viraraghavan T (2004) Treatment of pulp and paper mill wastewater—a review. Sci Total Technol 333:37–58. https://doi. org/10.1016/j.scitotenv.2004.05.017

25. Rathoure AK, Dhatwalia VK (eds) (2016) Toxicity and waste management using bioremediation. IGI Global, Hershey

26. Sharma SK (ed) (2015) Green chemistry for dyes removal from wastewater. Scrivener Publishing LLC Wiley, Beverley