A Review on Remove Nitrate Content from Water by Using Nitronet

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***Abstract*—Water is the major resource used by humans and every living being in the earth. Due to population increase, deficiency in water occurs. This caused the increase in the usage of ground water. For all the living matter, nitrogen is an essential element. Nitrogen with various oxidation levels is easily soluble in water which is highly toxic to human health. Ground water contamination by nitrate content increased due to the usage of high-level nitrate contained fertilizers for agricultural purpose. The other sources of nitrate contaminated water include landfill leachate, leakage of septic tank and municipal storm water runoff. Increased level of nitrate in drinking water affects. The hemoglobin which mainly cause blue baby syndrome for infants. It also provokes eutrophication and algal growth in water bodies. To reduce the nitrate level in water miscellaneous methods such as adsorption, ion-exchange, biological denitrification, chemical reduction and reverse osmosis are used.**

I. INTRODUCTION

Groundwater is one of the major resources for drinking and agricultural usage. Excessive use of nitrogen fertilizers in agricultural activities have increased the nitrate level in groundwater, which severely affects the health of human beings and this cause methemoglobinemia (MetHb), commonly called as "blue baby syndrome". Water is the major resource used by humans and every living being in the earth. Due to population increase, deficiency in water occurs. This caused the increase in the usage of ground water. For all the living matter, nitrogen is an essential element. Nitrogen with various oxidation levels are easily soluble in water which is highly toxic to human health. Ground water contamination by nitrate content increased due to the usage of high level nitrate contained fertilizers for agricultural purpose.

The other sources of nitrate contaminated water include landfill leakage, leakage of septic tank and municipal storm water runoff. Increased level of nitrate in drinking water affects the haemoglobin which mainly cause blue baby syndrome for infants. It also provokes eutrophication and algal growth in water bodies. To reduce the nitrate level in water miscellaneous methods such as adsorption, ion-exchange, biological denitrification, chemical reduction and reverse osmosis are used. From this adsorption is one of the lucrative and productive method which is manipulated to reduce the nitrate content in contaminated water.

A. Nitrate

Nitrate in water is a concern due to its potential health risks, especially when levels exceed recommended guidelines. Nitrates are nitrogen-based compounds commonly found in water, primarily as a result of agricultural runoff, wastewater discharge, or the use of fertilizers and manure.

Sources of Nitrate in Water:

- Agricultural runoff: Fertilizers containing nitrogen can leach into groundwater and surface water, particularly after heavy rainfall.
- Wastewater: Improperly treated sewage or animal waste can contribute nitrates to water sources.
- Industrial processes: Some industrial activities also release nitrates into water bodies.

B. WHO Guidelines for Nitrate in Drinking Water

The World Health Organization (WHO) provides international standards and guidelines for water quality to safeguard human health. These guidelines are particularly important in addressing the risks associated with nitrate contamination in drinking water. The WHO nitrate guideline is primarily based on the risk of infant methemoglobinemia, also known as blue baby syndrome. Infants under six months are especially vulnerable to nitrates, which, once ingested, are reduced to nitrites in the body. Nitrites oxidize hemoglobin to methemoglobin, reducing the blood's oxygen-carrying capacity. Although the 50 mg/L limit is conservative, it also considers daily intake levels, body weight, and water consumption in sensitive populations.

For reference, different regulatory bodies set similar standards:

- U.S. Environmental Protection Agency (EPA): 10 mg/L (as NO_3^--N)
- European Union (EU): 50 mg/L (as NO_3^-)
- Bureau of Indian Standards (IS 10500:2012): 45 mg/L (as NO_3^-)
- World Health Organization WHO = 11.3 mg/L (as NO_3^--N)

II. STATE OF DEVELOPMENT

Wael S. Al-Rashed et. al. (2022)
Nitrate is considered one of the key contaminants in drinking water sources, particularly groundwater. This could be a result of excessive human activities. Numerous studies have been successfully developed and are still developing eco-friendly and cost-effective treatment techniques for highly efficient nitrate removal from drinking water. Although most of the nitrate removal techniques are physically and chemically based, for example, ion exchange and reverse osmosis, biological treatment is an equally potent approach applied in full scale through autotrophic and heterotrophic denitrification. However, many studies are trying to reduce some of the disadvantages of the biological treatment, such as the need for further treatment for microbial or organic carbon removal. This paper addresses some of the conventional nitrate removal approaches and reviews the biological denitrification processes, highlighting the advantages and disadvantages of the following methods: (i) conventional nitrate removal techniques, (ii) biological denitrification via bioreactor membrane techniques, (iii) membrane bioreactor (MBR), (iv) membrane biofilmreactor (MBfR), (v) ion exchange membrane bioreactor (IEMBR), and (vi) biofilm-electrode reactor (BER).
Anoop Kapoor et. al. (1997)
Nitrate concentrations in surface water and especially in ground water have increased in Canada, the United States, Europe, and other areas of the world. This trend has raised concern because nitrates cause methemoglobinemia in infants. Several treatment processes including ion exchange, biological denitrification, chemical denitrification, reverse osmosis, electrodialysis, and catalytic denitrification can remove nitrates from water with varying degrees of efficiency, cost, and ease of operation. Available technical data, experience, and economics indicate that ion exchange and biological denitrification are more acceptable for nitrate removal than reverse osmosis. Ion exchange is more viable for ground water while biological denitrification is the preferred alternative for surface water. This paper reviews the developments in the field of nitrate removal processes.
Fatemeh Zirrahi et. al. (2024)
During the last few decades, several global crises including limited water resources, massive contamination of water resources, and available water bodies with high TDS have made researchers use new and advanced technologies to improve water quality. Since RO technology is proven to be a capable method in the removal of both anions and cations from water, the current systematic review was conducted to evaluate the efficiency of RO to provide a suitable approach for managers and health officials to solve the problem of increasing nitrate concentrations in drinking water sources. 2743 articles and theses were included in the primary search. Following screening and final restrictions that took the goals of the review into account, 61 presented studies were chosen for coverage. Among the 61 selected articles and theses, 54% of studies were conducted on groundwater, 25% of studies used BW-high rejection membrane, 58% of studies used polyamide membrane, 59% of them used spiral wound modules. The mean concentration levels of NO3 in the inlet-outlet and nitrate removal rate of the RO process were 145.7 and 20.8 mg/L and 85.03, respectively. Based on the proposed regression model, various variables including the type of environment to be treated, nitrate concentration at the inlet of the treatment system, the type of applied membranes, the area of the membranes and the pH value of the water showed a significant relationship with the concentration of nitrate at the outlet of the treatment system. The optimal conditions were the type of brackish water-low differential pressure membrane, the basic materials used for the manufacture of the membranes like polyamide/single-wall carbon nanotubes, the operating pressure of 5 bar, the area of the membrane of 2.6 m2 at a pH of 7.

Lizmol A. Peechattukudy et. al. (2017)
Nitrogen is present in atmosphere and is essential for all living things. However excess nitrate-nitrogen present in water can lead to adverse effects on living beings. Nitrate is the most common anion to be found in groundwater. Water quality monitoring in various states and countries conducted in groundwater survey around the world showed varying concentrations of nitrate. Most of the places, the concentration is within USEPA standards of 10mg/L nitrate-nitrogen (45mg/l nitrate according to Bureau of Indian Standards). However, some isolated cases showed spike in nitrate concentration in water mostly due to presence of wastewater disposal sites, landfills and septic/solid disposals. Consumption of nitrate contaminated water can affect livestock and humans especially babies and pregnant women such as methenaglobemia in infants. Various treatments have been found for removing

ground nitrate from groundwater. Most cost effective and efficient method is adsorption.

S. Dey et. al. (2021)

The presence of pollutants in aqueous solution mainly from hazardous heavy metals and metalloids is creating an environmental and social problem. The ammonia and nitrates are one of the major groundwater contaminants present in the rural areas. A nitrate was regulated in drinking water quality mainly due to excess amounts can cause methemoglobinemia disease. Ammonia in both gaseous and liquid form can be irritating to the eyes, respiratory tract failure and skin due to its alkaline nature. The biological effects of ammonia and nitrates in humans after acute exposures are dose-related depend on their concentration; the amount is taken by the body and duration of exposure. Biosorption is a physiochemical process that occurs naturally in certain biomass which allows it to passively concentrate and bind contaminants onto its cellular structure. It is metabolically passive process not require energy and amount of contaminants in sorbent can remove is dependent on kinetic equilibrium and composition of the sorbents at cellular surface. Every biosorbent had different physical, chemical and biological properties for heavy metals removal by biosorption from the water. The oxygen functional groups are very important characteristics of biosorbents because they measured the surface properties and hence their quality as biosorbents. The analysis of isotherm data by fitting them to different models is important to find a sustainable model that can be used. From the biosorption isotherms describe how the sorbate molecules are distributed between the liquid phase and solid phase when the system reaches equilibrium. The process can be made economical by regenerating and reusing of biosorbent after removing the metals. Various bioreactors can be used in biosorption for the removal of metal ions from large volume of water.

Sanjiv Tyagi et. al. (2018)

Nitrate is a water pollutant whose removal from water is necessary to lessen pollution and prevent damage to life. Several conventional techniques such as adsorption, ion exchange process, reverse osmosis, electrochemical, chemical, and biological methods have been developed for removal of nitrate, however they have several limitations such as requirement of post-treatment, less efficiency, and high installation costs. The field of Nanotechnology has observed tremendous growth in the past and has many environmental applications such as the use of nanomaterials for soil and water remediation, filtration of pollutants, water purification, biosensors, and in desalination. Recently, Nanotechnology has emerged as an excellent alternative for nitrate removal over conventional techniques. Nanomaterials due to their small size have large surface area and thus have high reactivity which, enables them to be used as reducing agents and adsorbents. This review focuses on the use of different nanomaterials especially nanoparticles, nanotubes, nanofibers, nanoshells, nanoclusters, and nanocomposites for removal of nitrate from an aqueous system. The limitations of using such nanomaterials for removal of nitrate and possible techniques to overcome these limitations have been discussed as well.

N.Sudha et. al. (2023)

Inadequate treatment of groundwater before consumption can be harmful to human health and the environment. We use a lot of water and produce a lot of trash, both of which can be harmful since they include various microorganisms, inorganic substances, and organic compounds. Unsafe ground water effluent results from a variety of physiochemical processes. The soil and water are degraded when chemically polluted ground water mixes with these natural resources and the ecosystems they rely on. The goal of this research is to identify the most efficient strategy for purging toxins from underground water supplies. Effluent guidelines and laws for wastewater treatment plants have been implemented by a number of protection authorities across the world based on performance and control technologies. There are three phases of Treated Waste Water (TWW). TWW treatment that can be distinguished from one another. In the past, TWW removal from water supplies was accomplished using adsorption, flotation, ozone, ion exchange, and crystallization. No longer are these methods often used. Water from the ground can be gathered and possibly reused in manufacturing processes utilizing cutting-edge wastewater treatment techniques. This review artlicle provides a literature overview on the common and actual features of ground water, including its ingredients such the chemicals used to create simulated ground water with dust and the treatment techniques used to deal with the effluents. This evaluation examines the literature to determine the most efficient absorbent method for detoxifying ground water of nitrates. Activated carbon derived from Acalypha indica, it is found, is a very effective absorbent.

Ali Ahmad Aghapour et. al. (2016)

Nitrate is an acute and well-known hazardous contaminant, and its contamination of water sources has been a growing concern worldwide in recent years. This study evaluated the feasibility of nitrate removal from water using the traditional coagulants alum and ferric chloride with lower concentrations than those used in the conventional coagulation process. In this research, two coagulants, alum and ferric chloride, were compared for their efficiency in removing nitrate in a conventional water treatment system. The removal process was done in a batch system (jar test) to examine the effects of coagulant dosages and determine the conditions required to achieve optimum results. The results revealed that ferric chloride at an initial dose rate of 4 mg/L reduced nitrate concentration from 70 mg/L to less than the World Health Organization (WHO) guideline value (50 mg/L N-NO3). However, the removal efficiency of alum was not salient to significant nitrate reduction. In conclusion, ferric chloride was more effective than alumin removing NO3, even in common dosage range, and can be considered a cost-effective and worthy treatment option to remediate nitratepolluted water. Furthermore, the removal of nitrate by coagulation can be simple and more economical than other treatment alternatives.

S. Ramalingam et. al. (2021)

In the present study, the effective removal of nitrates from the water was investigated using the nano alumina adsorbent and then the electrochemical method for the removal of nitrates using Pt anode and brass cathode were studied. Nano alumina has been used as an adsorbent to remove nitrates from aqueous solutions. The effects of contact time, adsorbent dosage and initial nitrate concentrations on the adsorption process have been investigated. The effects of pH and temperature on adsorption have been studied in order to optimize the range. Furthermore, the electrochemical method for the removal of nitrates using a Pt anode and a brass cathode has been observed to produce excellent results. The nitrate removal efficiency increases with electrolysis time in the current density range from 1 to 2 A dm-2 . Maximum nitrate (NO3 -) ions removal was achieved for nitrate (NO3 -) ions concentrations of 200 mg/L after 90 minutes of electrolysis at a current density of 2 A dm-2 . Direct nitrate reduction is possible at all nitrate concentrations and begins at a potential below 300 mV vs. saturated calomel electrode (SCE) in the cyclic voltammetry (CV) studies. From the CV and differential pulse stripping voltammetry (DPSV) studies, we have known that electrocatalytic reduction has a direct relationship between current and electrode potential. In CV, the electrode potential was found to be below 300 mV and DPSV showed that an electro-catalytic reduction occurred at a potential of 300 mV. From these studies, we infer that NO3 - ions are adsorbed on platinum electrode surfaces and desorbed from the surface. The adsorbed NO3 - ion is converted into NO2 - (nitrite) ions on the electrode surface (this is the rate-determining step) and the NO2 - ion is converted into NO, N2O, and finally into N2 gas.

Yufeng Jiang et. al. (2024)

Nitrate pollution in groundwater is a serious problem worldwide, as its concentration in many areas exceeds the WHO-defined drinking water standard (50 mg/L). Hydrogen-oxidizing bacteria (HOB) are a group of microorganisms capable of producing single-cell protein (SCP) using hydrogen and oxygen. Furthermore, HOB can utilize various nitrogen sources, including nitrate. This study developed a novel hybrid biological-inorganic (HBI) system that coupled a new submersible water electrolysis system driven by renewable electricity with HOB fermentation for in-situ nitrate recovery from polluted groundwater and simultaneously upcycling it together with CO2 into single-cell protein. The performance of the novel HBI system was first evaluated in terms of bacterial growth and nitrate removal efficiency. With 5 V voltage applied and the initial nitrate concentration of 100 mg/L, the nitrate removal efficiency of 85.52 % and raw of 47.71 % (with a broad amino acid spectrum) were obtained. Besides, the HBI system was affected by the applied voltages and initial nitrogen concentrations. The water electrolysis with 3 and 4 V cannot provide sufficient H2 for HOB and the removal of nitrate was 57.12 % and 59.22 % at 180 h, while it reached 65.14 % and 65.42 % at 5 and 6 V, respectively. The nitrate removal efficiency reached 58.40 % and 50.72 % within 180 h with 200 and 300 mg/L initial nitrate concentrations, respectively. Moreover, a larger anion exchange membrane area promoted nitrate removal. The monitored of the determination of different forms of nitrogen indicated that around 60 % of the recovered nitrate was assimilated into cells, and 40 % was bio-converted to N2. The results demonstrate a potentially sustainable method for remediating nitrate contaminant in groundwater, upcycling waste nitrogen, CO2 sequestration and valorization of renewable electricity into food or feed.

III. FINDING OF LITERATURE

Removing Nitrate Content from Water Using Nitronet likely refers to a specific technology or material designed to efficiently remove nitrates from contaminated water sources. Though "Nitronet" isn't widely recognized in standard water treatment literature, it may refer to a specialized filtration or adsorption technology designed to target and reduce nitrate levels. Identifying gaps in the research or approach for removing nitrate content from water using a method like Nitronet involves evaluating both the current technologies and the challenges associated with them. Nitronet could be a technology or method that uses a specific filtration or chemical process to remove nitrates. By addressing these gaps, Nitronet could become a more reliable, scalable, and efficient solution for removing nitrate content from water

IV. THE SCOPE OF WORK

This study focuses on evaluating the effectiveness of Nitronet**,** a novel adsorbent material, for the removal of nitrate (NO_3^-) from contaminated water. The scope of this research is limited to laboratory-scale experiments and does not include pilot-scale or field applications. Batch adsorption experiments to evaluate nitrate removal efficiency under varying conditions such as pH of the solution. The pH value of water containing nitrate (like from sodium nitrate or potassium nitrate) depends on the specific nitrate compound and its concentration, but nitrate itself (NO_3^-) is the conjugate base of a strong acid (nitric acid, HNO_3), meaning it's generally neutral in water

Nitrate Compound	Approximate pH in Water
Sodium nitrate ($NaNO_3$)	~7 (neutral)
Potassium nitrate (KNO_3)	~7 (neutral)
Ammonium nitrate (NH_4NO_3)	~5–6 (slightly acidic)

In this study we will test actual nitrate-contaminated water (like from fertilizer runoff), the pH could vary depending on what's mixed with it not just the nitrate.

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