Review Paper

Removal of Nitrate Loads Pollution from Drinking Water by Using Different Aromatic Grasses: Green Technology

ABSTRACT

The rapid increase in population needs a vast amount of food and energy to survive. This review paper reveals the potential of aromatic grasses to remove nitrate loads from different sources of contaminated water. A sustainable development approach for growing food needed pure water for irrigation and drinking purposes. These days, farmers are using chemical fertilisers to increase the quantity of food energy without knowing its harmful effect: our challenge is to be aware of them with green technology and teach them how to use it sustainably. Currently, many countries are experimenting with the green approach with the help of plants; they are trying to eliminate harmful elements from contaminated water. This method of removing pollutants by plants use is known as phytoremediation. So, many countries are using it to accumulate and extract toxic substances like heavy metals and higher nutrients load from water with the help of this approach. These aromatic grasses have been identified most photo-stabiliser, hyper-accumulator, and hyper-extractor of the toxic substance and nutrient loads at contaminated sites without harming or negatively impacting these toxics to other parts of the plant. Aromatic grasses cost-effectively have higher economic value. Many studies observe that toxicity enhances the essential oil quality of these grasses and increases the value and quantity of oil. Thus, grasses are very suitable for removing nitrate from different contaminated water sites and may be they are option for ideal sustainable development approaches.

Keywords: Aromatic grasses, Contaminated, Environment, Phyto-Remediation, Sustainable, Wastewater.

1 INTRODUCTION

Pure water scarcity is a significant problem to national and international constancy, natural health, food supply, and even becoming a water war in the upcoming future for the universe level. The population of India is the second-highest in all over the world. Rapid population increases required a higher amount of agricultural land to fulfill the need for food energy. Indian farmers are under heavy pressure to grow a massive quantity of food yield; for this, farmers use a higher amount of chemical fertiliser and pesticide (shown in figure1) to increase the yield, making harvest easy to equaling the need for food energy.

However, using these chemicals for an extended period resulted in declining water sources (like a river, lake, surface water, and groundwater) quality and increased the level of nitrogen and phosphorous in water bodies of the Indian district. Researchers revealed that more than 50 percent of Indian districts exceed the permissible level of nitrogen in water (Times of India **[1])**. More than 350 districts of the Indian

Figure 1 Excess amount of chemical fertilizers used in agriculture fields
Source: [1]

communities were affected by nitrate pollution in drinking water followed by fluoride, Iron, Salinity, Arsenic Lead, Cr, and Cd, data given in figure 2.

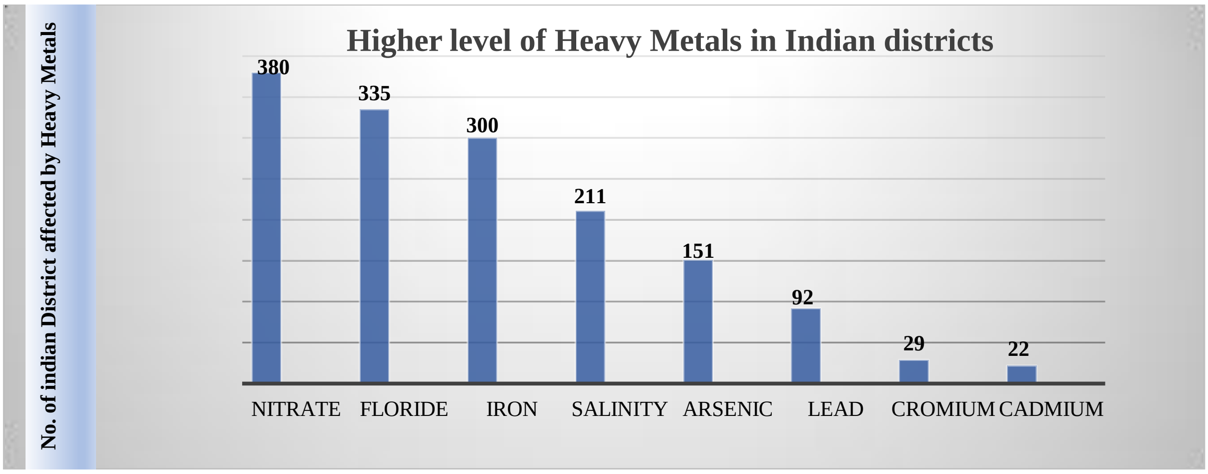

Figure 2 Sophisticated load of nitrate and other polluted found in different districts of India.
Source: Times of India

The natural composition of water, like groundwater and surface water, has become degraded by anthropogenic activities. Because of the rapid growth of urbanization, industrialization, and overpopulation, the generation rate of municipal, industrial, and sewage wastewater is very high. Due to India's lack of treatment facilities, social workers were forced to shed this untreated wastewater to direct discharge into an aquifer. This untreated wastewater is a leading cause of water pollution and becomes a significant source of organic and inorganic pollutants. The process by which this contaminated water reaches into the groundwater and surface water may be by drainage, leaching, leakage, and agriculture runoff during monsoon, affecting water quality and increasing nitrate and phosphorus loads in water. Approximately more than 23% of nitrogenous compound discharge from agriculture runoff this data was shown in figure 3. Compared to other causes of nitrate pollution, farmers and self-owner employees use nitrate-bearing chemical fertilizer for their fields; farmers applied various pesticides, fungicides, and herbicides that may migrate and reach groundwater. Nitrogenous compounds are highly soluble and mobile in water; by this nature, nitrate and nitrites are common pollutants of groundwater in the rural and suburban areas of Indian communities.

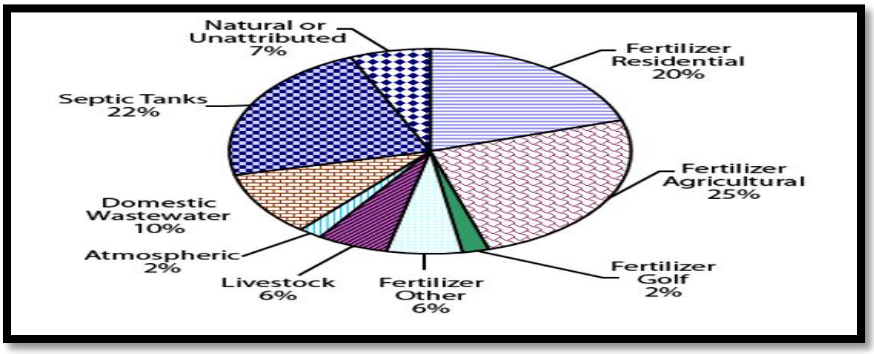

Figure 3 Significant sources of nitrogen generation from different areas.

Unpolluted water for drinking is the primary requirement for every human being. Surface water is blue water present on the top of the earth surface, such as rivers, lakes and wetlands. The water precipitation and evaporation process is the primary producer of surface water by this water cycle moving into the ground, becoming groundwater. In India, rural population largely depends upon groundwater sources for drinking. However, these days' groundwater resources are not fit for safe drinking purposes. All of these have been highly contaminated by nitrate, fluoride, iron, manganese, salinity and other toxic metals. If all existing sources in the village have such problems, the selected water sources need suitable treatment, depending upon the nature of the problem parameters. Not only rural area but urban area also depends on groundwater for irrigation and drinking purpose.

Indian urbanization is growing fast, approximately more than 33.40 % from 2010 to 2020 **[2]**. Due to which they generate a higher amount of wastewater, the urban society of India produced point and nonpoint sources, mainly contaminated groundwater and nonpoint sources from different areas **[3]** with lack of water and sanitation system contamination become much higher. The physiological importance of trace elements in agriculture is well known. Some stuff like B, Fe, Cu, and Mn are considered essential micronutrients. Still, if the concentration level of these macro and micronutrients increased, it shows the opposite effect on water, soil, and air. The groundwater quality was maintained by different ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, phosphate, and fluoride. These ions are present in the form of the anion. Both cations and anions are responsible for maintaining the quality of water.

Nitrate (NO_3) is made of nitrogen and oxygen, a naturally occurring chemical compound. It is highly soluble in water and naturally found in nitrate salt on earth at large deposits known as sodium nitrate. Natural Nitrogen may be fixed from the atmosphere by nitrifying bacteria and it contains more than 78% nitrogen which was reserved in the atmosphere. Nitrate nitrogen is of prime importance for plants, and it is naturally found in soil and water (shown in figure 5). The most important source of nitrate-nitrogen is the fertilizer and manure used in the nearby fields, along with the dead animals and plants decomposing there in. Many nitrogen-bearing compounds, like ammonium, ammonia, nitrite, and nitrate, are commonly present in consumption water and also found these compounds in various agricultural, domestic, and industrial wastewaters **[4, 5]**. These pollutants, which were directly discharged into water bodies, increased loads of macronutrients in surface water which leads to a higher amount of nitrogen and phosphorus, which are the main factor causing eutrophication in aquatic bodies.

Figure 4 Grasses have the potential to accumulate various adverse environmental effects**.**

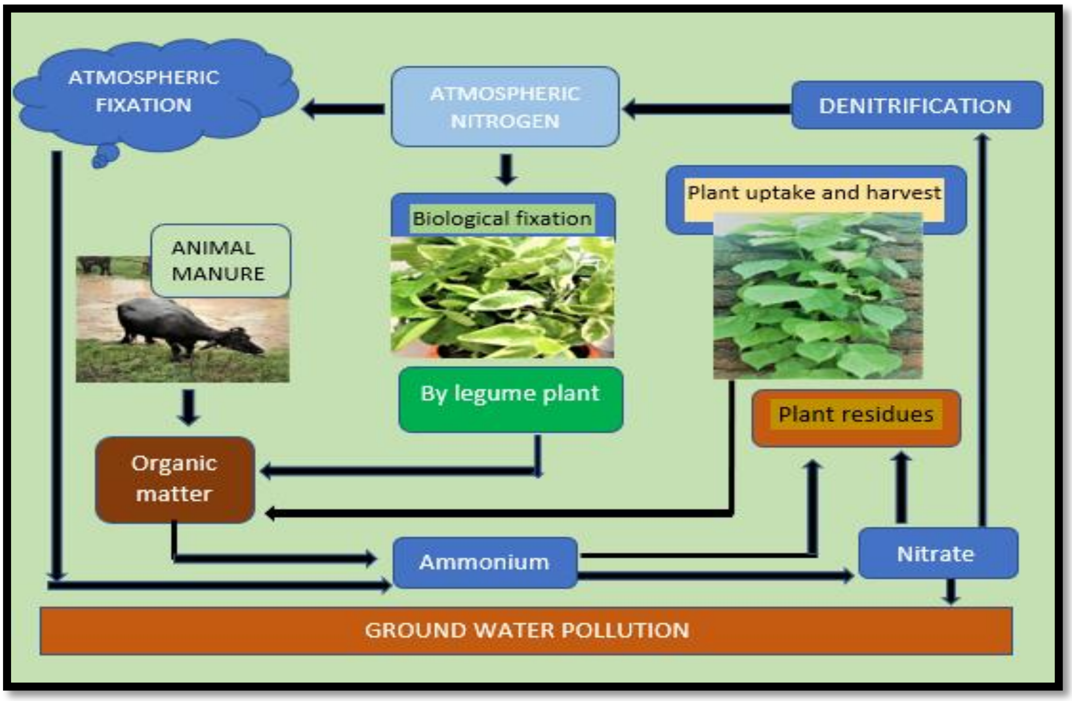

Figure 5 Nitrogen cycle—a gaseous cycle with the major reserve in the atmosphere (N_2: 78%)**.**

Source: Independent (self-created)

Researchers observed a large amount of nutrient discharge in water bodies by nonpoint sources, such as agriculture activities responsible for eutrophication which affects aquatic life **[6].**

This is a challenging situation for surface water quality because excess nutrients discharged in water is a food source for microorganisms and algae. A higher population of algae will create a problem where sunlight is unable to enter the water, which disturbs the balance of dissolved oxygen devastatingly. At the same time, an aquatic organism will die off. This condition increases the volume of decaying organic material and increases the population of microorganisms and bacteria; these organisms will consume more oxygen, leading to the decline of the total amount of dissolved oxygen in the water. This condition lower the level of oxygen, this state of water is called eutrophication; at this level, many aquatic insects and fish are unable to survive **[7]**.

Nitrogen is essential for all living things in lower concentrations, but high nitrate-nitrogen levels in water are not suitable to be potable. Nitrate is a life-threatening compound of nitrogen found in water and soil. Nitrates are inorganic compounds whose flexibility and constancy make them highly hazardous in aerobic systems such as underground water. Nitrate levels up to 3 parts per million (ppm) are found naturally in healthy water as in lower risk of water contamination. Still, a water test with a high nitrate concentration is not recommended for families with newborns, expecting women, nursing mothers, or older people because these groups are the most vulnerable to nitrate. Nitrate polluted water supplies have also been connected with outbreaks of infectious diseases **[8]**.

Different health monitoring authorities like WHO, EPA agency, ICMR set the safe limit for nitrate consumption in drinking water; it is also called a permissible limit. Thus, the researchers can check water quality and decrease adverse effects on health **[9]**. According to water quality standards set by World Health Organization (WHO) **[9],** the guideline value for nitrate is ten ppm. The Indian Council of Medical Research (ICMR) **[10]** has suggested the highest desirable level of 20 ppm of nitrate in drinking water. The maximum permissible level recommended is 50 ppm data given in Table 1. High nitrate may cause methemoglobinemia, gastric cancer, thyroid disorder, miscarriages, congenital disabilities, and the development of some cancers in adults. Methemoglobinemia or blue baby syndromes was found predominant compared to other problems in all age groups in many districts of India. Due to higher consumption of nitrate in the body, which oxidises the iron in haemoglobin (acts as a carrier of oxygen in the blood) from ferrous iron $^{(2+)}$ to ferric iron $^{(3+),}$ this oxidation of iron reduces the transportation capacity of oxygen in the blood. This process decreases the oxygen level in the blood and causes severe respiratory tract infections-infants of six months old or younger mainly come at higher risk for this disease. The consequential condition is methemoglobinemia or "blue baby syndrome" **[8, 11-12]**.

Table 1 The acceptable limit of nitrate in potable water given by different authorities.

Organization	Conc.* as NO_3-N (mg/l)	Conc.* NO_3 (mg/l)	Source
WHO[a]	10	45	Latest guideline (1987)
US Environmental Protection[b]	10	45	Max. Conc. Level
ICMR (India)[c]	20	50	IS:10500 (1983)

Notes: [a]WHO -World health organization, [b]US-United states, [c]ICMR- Indian Council of Medical Research, Conc.*- concentration **Source: [13]**

Many countries are making efforts to reduce nitrate from water and wastewater. The task of environmentalists, engineers, and scientists is to develop effective and simple ways to treat contaminated groundwater and surface water; different accessible to all methods are trying to reduce the level of nitrate from dirty water and soil. Adsorption is a widespread removal process from contaminated water; it is an ascent process of gathering soluble substances present in the solution using different tricks and techniques. Many data showed that adsorption methods are not up till now used in wastewater decontamination. Still, demands for an improved superior method for treating wastewater runoff have led to an intensive examination and use of the procedure of adsorption by activated carbon. Activated carbon is a very luxurious adsorbent material to remove impurities, so other adsorbents must be investigated **[14, 15]**. Pomegranate extracts have started an improved range of applications in the arena of pollution control, based on their extraordinary selectivity in adsorption, but it required massive amounts of contaminated areas, which are tough to manage. Many other biological and chemical processes are there, such as natural treatment by using denitrifying bacteria, in this reaction oxidation process takes place and nitrate convert into nitrogen gas, chemical methods have a list of forms of removal of nitrate from water by reverse osmosis, distillation, electrodialysis, catalytic denitrification ion exchange process and so on. These removal technics are very expensive and required higher energy, chemicals, equipment, human power, etc., to show the results in a reduction in nitrate concentration. Therefore, we have to think and develop some cost-effective and easy to use for everyone methods out of these. Nowadays, phytoremediation as green technology is one of the primaries of ecologically friendly technologies scientists practice in their research.

2. Phytoremediation

"Phyto" means "plant", and "remediation" means "restoration" or "removal of contamination with the help of plant". In this process, no chemicals, no machine power are used for the removal of pollutants, but only suitable plants spices are used directly to clean up contaminated water, soil and air; phytoremediation is a new, easy, simple, affordable, fascinating pleasing and cheap suitable solution for many surroundings problems. Landmeyer **[16]** defines "phytoremediation is the application of plant in a controlled environment and their interactions with contaminated groundwater, organic and inorganic substances to achieve site definite remedial areas". Plants can reduce, absorb, extract, volatile, and translocate certain toxic substances and heavy loads of nutrients in their root, leaves, and shoots in less harmful forms in various parts **[17]**. Across the world, there are many countries like China, Vietnam, Australia, and other parts of the world using green technology (phytoremediation) to clean contaminated water and land **[18]**.

The environmental condition is stable at the time of using phytoremediation methods because in this actual condition is not affected, and in natural conditions, all the processes sustainably take place. When growing in contaminated sites, most plants convert their morphology, physiology, and anatomy according to the environment to stay alive; this mechanism of a plant is called a defence mechanism and dilution phenomenon **[19].** They can convert complex toxic compounds into more minor or simple compounds that lead to challenging situations explaining why different plants can grow in different environments. Remediation through plants is one of the fundamental approaches compared to various other methods of removing pollutants from soil and water; it cannot show any harm to the composition of the soil, and with time it enhances the superiority and fertility of the soil. In this methods removal of pollutants depend on selection and identification of suitable crop. The study was done by **[20]** that more than twenty plant species suggested that the nitrogen and phosphorous subtraction capacity depends on species selection.

2.1 Selection of crop required these points

- It cannot be used as a food crop.
- It should be surviving in adverse conditions.
- High production in biomass and removal efficiency will be increased.
- The bioaccumulation and adsorption value are high for that plant.

Many types of grass can accumulate and extract organic and inorganic pollutants from contaminated water and land. For example, according to many studies, grass blades effectively remove a higher amount of nitrogen and phosphorus from dirty water and land **[21].**

3. Using Aromatic plants in the race of phytoremediation

Aromatic plants have a unique aroma and flavors; many of them are used as medicinal crops. These crops are not eatables crops, but numerous plant species are cultured for their additional characters of aroma and flavors. As this plant is not part of the food chain, they are more feasible than food crops for phytoremediation. Moreover, they have high economic value due to their precise production of essential oil used in perfumes, cosmetics, small-scale agarbatti and doopbatti, industries, mosquito liquid, pain balm, and other fragmented product formation. Many aquatic plants and aromatics plants are in this phytoremediation race. Long ago, different aquatic plants are using for the removal of nutrient load from wastewater; they are water lettuce (*Pistia stratiotes*) **[22]**, duckweed (*Lemna spp.*), water hyacinth (*Eichhornia crassipes*), and others **[22, 23–24]**.

But unique space is occupied by aromatic grasses, just a while ago, aromatic plants have been verified for their potential for phytoremediation because it survives in harsh conditions, cannot be a part of the food chain, and potential to stabilise, accumulate, extract, and volatile toxic metals and nutrients loads from polluted sites and produce higher biomass, which enhances the essential oil quantity and quality—

aromatic grasses day by day increasing attention in the removal of nitrogen and phosphorous (shown in the table. 2) from contaminated water and soil **[25, 26]**.

Table 2 Potential of aromatic grasses for removal of nitrate and other pollutants from the different contaminated sources of water

Aromatic Grasses	Source of Pollutant	Nitrate Removal Efficacy	Other Pollutants	Economic benefit, extraction % of essential oil	Sourc
Lemongrass	from contaminated water and soil	reduce nitrogen and phosphorus	accumulate Cr^{+6} and As^{+3}	0.36 to 1% on fresh weight	[30]
Citronella gra	from contaminated water and soil	reduce nitrogen and phosphorus	multi-metals removals	0.4 to 1.1% on fresh weight	[32]
Palmarosa grass	from contaminated water and sewage sludge soil	reduce nitrogen and phosphorus	toxic elements, Ni, Pb Cd and Cr, are absorbed in the uppe and lower parts of a crop	0.7- 1.1 % on fresh weight	[31]
Vetiver grass	water contaminated by organic pollutants	reduce 27.5 mg/l 9.8 mg/l	BOD, phosphorus, TSS, multi metals removals	to 1.50 % on dry weight	[27]
	water contaminated by sewage effluents	reduce N 40-70% and other pollutar			[6]
	wastewater from a pig farm	reduce N 93.50%			[29]
	contaminated water by the overuse of chemica	tolerate N load u to 5500 kg nitroge ha^{-1} $year^{-1}$			[36]
	contaminated water an soil by industrials effluents	reduce N up to 93.90%			[34]

There are many species of aromatic grasses with high potential of biomass grown in adverse environmental conditions; more than 50 species are found of lemongrass (*Cymbopogon Flexuosus*); it has a quality to survive with toxic stress conditions if this cultivates for a lengthier period. A study investigated by **[27]** revealed that the lemongrass herb stays healthy if irrigated with wastewater and produces a higher essential oil yield.

The experiment done by **[28]** study revealed that *Cymbopogon Citratus* stem can adsorb Pb^{+2} ions from contaminated waters. Thus, it would be used as an effective adsorbent for wastewater containing a higher concentration of Pb ions. Another experiment reveals lemongrass's capacity to eliminate higher toxic elements from industrial effluents [**29**]. Studied completed by **[30]** *Cymbopogon Flexuosus* can accumulate Cr^{+6} and As^{+3} in satisfying amounts. Therefore, studies concluded that lemongrass could be used as a good crop for cultivation in polluted sites shown in Table 2.

Palmarosa (*Cymbopogon Martinii*), studied completed by **[31],** reveals the potential of Palmarosa for phytostabilisation in the removal of toxic substances from tannery sludge amended soil shown in Table 2.

Citronella (*Cymbopogon Winterianus*); these grasses are used in higher contaminated areas for photo stabiliser of heavy metals such as Cd and Cr from polluted water. Studied done by **[32]** disclose the removal ability of Cadmium by Citronella, and **[33]** also studied the removal capacity of chromium by *Cymbopogon Winterianus*. More experiments have to be done in the future to examine the absorption and uptake capacity of citronella and palmarosa grasses.

Among all grasses, Vetiver grass (*Chrysopogan Zizaniodes* L.) has been observed more suitable for the removal of nitrogen from wastewater. Australia and China, after the nineties, started the application of vetiver grass for the disposal of contaminated wastewater. Vetiver was used to absorb effluent and leachate from toxic landfills by different pollutants in Australia **[34]**; also, China effectively purified polluted river water using vetiver **[35, 36]**. Experiments have also revealed that vetiver shows higher potential for absorption of nutrients such as nitrogen (N) and phosphorus (P) in polluted water bodies **[37]**. After using vetiver in dirty river water, they show more than 70 per cent removal of nitrogen in 35 days and 98 percent removal of phosphorous in 30 days observed by **[35, 36].**

The remarkable result shown in the hydroponic system by using vetiver with sewage effluent removes more than 90 percent of N and P and reduces algal growth and feacal coliform **[38]**. Many studies are focusing on the reduction of nutrients using vetiver grass has been achieved higher growth in respect to the efficiency of the refurbishment of waste generated from sewage, industrials wastewater **[39]** iron ore mine soil **[40]**, municipal solid waste leachate **[41]**. Scientists **[39]** experimented that vetiver grass reduces all pollutants by (62-100%) and mainly nitrogen was recorded less from 27.5 mg/l to 9 .8 mg/l, from sewage effluent. More evidence observed that 40-70% of total nitrogen was removed within 2 to 4 days **[6]** using vetiver grass in contaminated water. Various studies explore the potential of vetiver grass as a suitable candidate to remove higher loads of nutrients from contaminated drinking water.

4. Benefit of aromatic grasses

The farming of uneatable aroma plants always is suggested for cultivation in polluted areas because they are beneficial, feasible, easy to grow and workable crops. The advantage of using aromatic plants for phytoremediation resolve can be considered under three main titles a health benefit, environmental view and economic view.

4.1 Health benefit

Aromatic plants have a significant health benefit if these crops are used in the phytoremediation process as a green technology. They decrease the health issues generated by a higher concentration of nitrogen, phosphorus, and toxic metals present in contaminated water and soil. These plants do not come in the food chain that is the most beneficial quality of these plants. The untreated wastewater was released directly into water bodies, where it leached out and decreased the flow of surface and groundwater. This poisonous water was absorbed by humans and other living things, and it caused a number of ailments like methemoglobinemia and blue-green algae blooms. The main cause of infant syndromes is too much nitrate in water, which also raises the risk of gastric cancer. Many studies confirmed that vetiver grass decreased the concentration of heavy metals and nitrogen, such as Cu by **[42]** Cr, **[43]** Pb, Zn, Cd **[44],** and nitrate up to 93.90% **[45]** from contaminated water. Therefore, if we use these plants in the contaminated area or discharge it into water bodies, it should be treated with these grasses. It would sustainably reduce health risks.

4.2 Environmental View

The aromatic plant is very effective in the environmental aspect because it can survive in adverse or harsh environmental conditions without harming soil, water, air, and other parts of plants. Toxic metal and higher nutrient concentrations can't affect essential oil quality and increase their biomass when cultivated in contaminated water or soil. Many studies revealed that vetiver and lemongrass could tolerate toxic environmental conditions, reduce soil erosion, pest control, and termite control, increase water quality and air quality, and enhance soil fertility **[46].** Vetiver was most effective in tolerating a higher load of nitrogen. It shows the positive impact at the high level of nitrogen supply up to 5500 kg Nitrogen ha^{-1} $year^{-1}$, without showing any adverse effect on crop development and quality of essential oil more than 9000 kg Nitrogen ha^{-1} $year^{-1}$. These qualities make vetiver highly appropriate candidates for treating contaminated water and other wastewater highly polluted by nitrogen **[37]**. The morphology and physiological feature of vetiver and lemongrass is unique. The plants have a long and thick root with a higher penetration system, rigid and inflexible stem, high tolerance range of toxic water and soil, and survive best in adverse conditions **[47].** It proved that it is one of the easy, cost-effective, and straightforward methods for many surrounded ecological problems **[48]**.

4.3 Economic View

Aromatic plants produce an essential oil that contains aroma and flavour; its demand is very high worldwide, expected to reach up to US $4 trillion in upcoming years **[49]**. Aromatic plants and grasses can mainly fulfil this demand. Aroma grasses can grow in polluted water and soil without any harm to essential oil. This feature of grass repairs the environment and increases the economy of our country **[50]**. Aroma crops are easy to grow, low maintenance, needless fertiliser, survive in any metrological condition, and also farmers are free from farm maintenance by which with insufficient effort they earn more. Moreover, scientists revealed that it is suitable for sustainably treating waste and polluted water.

5. Future Aspect

Restoration and reclamation of contaminated sites by aromatic grasses need more research and review to monitor the impact of phytoremediation methods on water, soil, air, and the environment. By using fragrant grasses for recovery of contamination, sites show an increased cost-benefit ratio and decreased risk of going hazardous substances in the food chain. But together with this, long-term investigation in the field is essential to check the improvement in soil quality along with other risk features. Besides, multifaceted efforts must be taken to judge the impact of these aromatic grasses to recognize the removal and accumulation mechanism of toxic elements and nutrients loads from contaminated sites. These crops have incalculable economic values; they can gain financial profits and other remunerative weight by growing them in polluted areas instead of eatable crops. Using these methods for an extended period enhance the drinking water quality with sustainable technique.

6. Conclusions

It is verified that aromatic grasses are an appropriate candidate for use in a contaminated sites such as sewage, domestic, municipal, and industries wastewater to remove nutrients loads and toxic heavy meats in an enviro-friendly method, cost-effectively. Aromatic plants have the countless potential for phytoremediation of polluted, infected sites. Using aroma grasses reduces poisonous chemicals, nitrogen, and phosphorus from dirty water, leading to increased quality of wastewater, reducing health impact, cutting a load of direct discharge of untreated waste into river bodies, and improving water quality through which it can improve surface and groundwater and many other benefits.

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