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Potential of Canna Indica in Root Zone Technology for Dairy Waste Water Treatment: A Review

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Abstract: ***This article summarizes research that looked at the use of root zone technology to remediate dairy effluent using Canna indica. Microbes, substrates, and plant types make up root zone technology. Anaerobic digestion is almost the only practical way to handle dairy effluent due to its high organic content. Nutrient absorption and incorporation into plant tissues occurs during this phase. They do this by releasing oxygen into the substrate, creating an environment where chemical oxidation and anaerobic microbes may flourish. Root zone technology that makes use of ornamental flowering plants, either in a monoculture or a combination of species, is suggested for its ability to improve the root zone's aesthetics and treat wastewater at the same time. Important functions performed by plants in CWs include providing a substrate for physical filtering of effluent, housing microbes on a vast surface area, and fueling bacteria with carbohydrates. They take in organic matter and incorporate it into plant cells. They do this by releasing oxygen into the substrate, creating an environment where chemical oxidation and aerobic microbes may flourish. Both the aesthetic value of the wastewater treatment system and the habitat they provide to animals are enhanced by these plants. Results from canna indica's use in CWs to remove pollutants from wastewater are promising. This report so summarizes previous research on Canna indica's efficacy in wastewater treatment and suggests directions for further study in this field.***

Keywords: constructed wetlands; Canna indica; emerging contaminants; wastewater treatment; phytoremediation, root zone technology

1. Introduction

Significant reduction of pollutants in wastewater requires evaluation and improvement of the treatment efficiency of current wastewater treatment plants. There is a significant amount of contamination in dairy waste water, which is bad for the ecosystem. Approximately 2% of the milk that goes into processing ends up in landfills, and the industry is responsible for producing 6-10 l of effluents per liter of milk. Particulate organic matter (COM) consists mostly of lipids, proteins (casein), and carbohydrates (lactose) that breakdown further in wastewater to form a foul-smelling black sludge. Toxic to aquatic life, it has been discovered. In addition to promoting eutrophication, imparting color, decreasing dissolved oxygen, and causing taste and odor, they also enhance turbidity. While our nation does have a number of environmentally friendly treatment projects underway for various industrial and domestic wastewaters, such as constructed wetlands, aerobic biological treatment units, ecological floating beds, filtration, aquatic plant restoration, and microbial remediation, these methods are not optimally designed to eliminate contaminants. Several issues, including as overloading, clogging, and ineffective removal of certain contaminants, surfaced midway through the treatment process. Consequently, we need to find a more cost-effective and environmentally friendly on-site treatment method. A man-made structure that treats water and wastewater is called a constructed wetland (CW). Microbes, substrates, and various plant species make them up [11]. Their mechanism of action is based on recreating the characteristics of natural wetlands inside a relatively artificial setting [60]. "The physical, chemical, and biological processes that enable CW to purify water and wastewater are numerous [61,62]. Root zone, also known as rhizosphere, is the active response region of the CWs. Soil, contaminants, microbes, and plants all work together to trigger a cascade of biological and physicochemical reactions here [63]. Hydraulic loading rates, water retention duration, water depth, CW design and construction, feeding mode, and other essential operational parameters all impact the efficacy of CW treatments [60]. More and more wastewaters, such as those from industries, farms, and homes, as well as landfill leachate and rainfall runoff, are finding CWs to be an attractive treatment alternative [11,64,65,39]. Carbon, nitrate, phosphate, and heavy metal removal are all successfully accomplished by these methods, according to many studies [40,41]. The low running and maintenance costs of CW systems are one of its major advantages [42,43].

Most people agree that plants are very important for cleaning CW wastewater of pollutants. [43].

1.1 Plants Used in CW

Literature suggests that Phragmites australis, a plant with a high biomass and tolerance for a wide range of water conditions, is the most popular choice for CW. [03,06], Typha latifolia which is effective in nutrient uptake and providing habitat for micro organisms, and Cyperus papyrus [53, 54, 55, 56, 57] bulrushes which is good for nutrient removal and providing habitat for beneficial bacteria, duckweed which is a small floating plants that absorb nutrients and provide shade and reduce algae growth ,water hyacinth which is a fast growing floating plants that can remove heavy metals and nutrients from water, water lilies provide surface cover and habitat for aquatic organisms while absorbing nutrients. As an alternative to CW, canna indica is now the subject of research [44]. The main advantage of the canna plant over the typically used Phragmites australis for CWs is its rapid growth and high biomass output [39]. Nitrifying bacteria thrive in rapidly expanding plant communities with extensive root systems, which increases the surface area of the biofilm due to the rapid development and high biomass of these communities [49]. Compared to other wetland plants, cannas need three to five times as much water. Its appeal and blooming qualities also make it useful in other contexts. [55].

1.2. Features of Canna indica

Canna indica is able to remove more debris from the CW because its fibrous root structure creates high aerobic conditions [57]. Its root system is much superior to that of other plant species in terms of root development, root number, root biomass, and root surface area. The root system of this plant is quite extensive, and it is very resistant to contamination [58]. The herbaceous shrub may reach a height of 1.5 meters when planted in soil. Emerging from a subterranean rhizome, the plant's encased main stem bears light-green, 25-50 cm long leaves. This rhizome is thick and has branches. A crimson blossom with a yellowish lip Inflorescences with simple or branching spikes yield flowers that are 4-4.5 cm long. It also has medical use. It has the potential to alleviate menstrual cramps. The root has anti-gonorrheal and anti-armenorrheal properties. Traditional Nigerian medicine for gastrointestinal disorders includes grinding the root into a powder and taking it orally. Additionally, the blooms are used as a remedy for malaria.

2. Removal of Nutrients, COD, BOD5, TDS and TSS

The addition of Canna indica to CWs has been shown in several studies to efficiently remove total suspended solids (TSS), nutrients, and oxygen demand indicators (BOD5, COD, TN, TP, and TP, respectively). The performance results from several experiments fluctuate because to variations in pollution influent loads, CW flow types, and ambient conditions. According to [65], these characteristics greatly affect CW efficiency. Nutrient removal is enhanced when the hydraulic retention time is longer or the hydraulic loading rate (HRT) is slower [11,20]. This is because there are more interactions between roots, substrates, and nutrients. Among the CW kinds mentioned, VSSFCW is the most commonly used. The inability of HSSFCWs to transmit oxygen is one of its many drawbacks. As water flows vertically between layers to the base of beds, enabling air to penetrate the pores, a rapid oxygen transfer rate aids in nitrification and the removal of organic waste [21,22]. However, studies comparing the efficacy of different Canna indica CW designs side by side are lacking. When evaluating the efficacy of various Canna indica-planted CW designs, it is crucial to take into account the following factors: soil type, wastewater supply, feeding strategy, hydraulic retention period, and hydraulic loading rate.

3. Removal of Heavy Metals

Heavy metals, defined as metals having a density more than 5 g/cm3, are harmful to ecosystems and all kinds of life on Earth [27,28]. In addition to being highly conductive, malleable, and brilliant, metals are also excellent at forming cations by releasing electrons. The earth's crust is a common place to find heavy metals in nature [29]. Changes in surrounding concentrations are caused by variations in the composition of heavy metals, which vary by location [30]. The poisoning of our environment with heavy metals is becoming a major concern [31]. They pose serious threats to human and environmental health since they are not biodegradable and accumulate in living things as they move up food chains [32]. Some of the harmful pollutants have reached dangerous levels, and heavy metals are one of them. Various metals, including silver, gold, cadmium, zinc, selenium, and nickel. Mercury (Hg), uranium (U), chromium (Cr), and lead (Pb) are a few heavy elements that should be taken into account [33].

Heavy metal removal from wastewater has been the subject of research into a variety of technologies, including bioreactors, membrane filtration, nanotechnology, and biodegradable polymers. [34,35].

4. Removal of Fluoride

A Pauling Scale electronegativity of 3.98 makes fluorine very reactive [1]. It is also the most electronegative element. Rather from being present in its pure form, this property causes the element to be found in the environment as different mineral salts [22]. Fluoride intake of more than 1.5 mg/L from food and/or drinking water (according to WHO) and 4.0 mg/L (according to Tanzania Bureau of Standards, TBS) has been linked to skeletal abnormalities like dental fluorosis and enlarged skulls, as well as changes in various physiological processes [23]. Multiple research examining the effects of fluoride in water on development, reproduction, and longevity have shown that chronic fluoride exposure significantly lowers fertility. [24]. Because of this, keeping an eye on and regulating fluoride levels in aquatic systems is crucial.

A number of microphytes have been shown to be capable of removing fluoride from water. These include Canna indica, Epipremnum aureum, Cyperus alternifolius, and Cyperus rotundus. [3]. Canna indica had a fluoride removal rate of 95 percent, Epipremnum aureum of 52 percent, Cyperus alternifolius of 65 percent, and Cyperus rotundus of 56 percent. Cannas and calamus planted in CW were more successful in eliminating fluoride than wetlands without plants, according to the research. [53, 26].

5. Conclusions

The majority of researchers agree that plants have a significant role in the treatment of CW wastewater. Canna indica showed promise in the investigation of water purification for the elimination of organic pollutants, heavy metals, and minerals. Canna indica's efficacy in CW systems for pollution removal was the primary emphasis of the review. Despite the abundance of data, several questions about this plant's efficiency in CW remain unanswered". The following areas need more investigation:

1) More research into the processes that remove various pollutants is needed, particularly for new toxins.
2) Research on the microbial diversity in CWs grown with Canna indica has to be expanded. The major emphasis

here should be on how plant-microbe interactions affect CW performance.

3) Canna indica needs to have its effects studied in relation to the presence of toxic pollutants in wastewater. This is especially the case when it comes to pollutants that have the potential to bioaccumulate or bioconcentrate inside the plant's tissues.
4) Plant competitiveness affects the performance of investigations using Canna indica when it is mixed with other plants. So, it's decided whether to utilize a mixed system or a monoculture.

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