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Review on wastewater reuse for irrigation towards achieving environmental sustainability

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ABSTRACT

Even though water makes up around 70% of the earth's crust, just a small portion of it is suitable for terrestrial life. Water is essential for life. The small percentage of freshwater with low salt concentration in the Antarctic and Arctic (68.7%) is only 2.5% of the total water stock in the hydrosphere and is largely in the form of ice and permanent snow cover. This writing serves as a review. Journals, publications, and earlier project works pertinent to the subject at hand were thoroughly examined and strategically sampled. To gather the data needed for the paper's creation, many works were examined and summarized. Agriculture is a large consumer of wastewater globally. It is believed that finding suitable irrigation resources is crucial for protecting natural water bodies and ensuring food safety. Wastewater reuse has emerged as a practical option for pollution reduction when water reuse replaces effluent discharge to vulnerable surface water bodies, preserving and extending available water supplies. This is due to the difficulties associated with the discharge of untreated wastewater into the environment. As treating and utilizing wastewater for irrigation would make it easier to achieve sustainability, using wastewater for irrigation is an efficient strategy to lower costs and improve environmental health and safety in today's economy.

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1. INTRODUCTION

Reusing wastewater for irrigation is mainly viewed as an unavoidable solution to address water shortages in poor nations. So, wastewater is frequently used to irrigate crops in these nations. Due to the growing shortage of freshwater resources in many dry and semi-arid countries, the centuries-old practice of using wastewater in agriculture in urban areas is garnering renewed attention .[1]

Water whose quality has been reduced as a result of human activity is referred to as wastewater. The term "domestic liquid waste" refers to waste from homes, companies, and agriculture. It includes a wide spectrum of contaminants that could be dangerous or have concentrations that could lower the quality of the water. Bathroom soaps and detergents, cooking oil, food waste, and other human activities requiring the use of water are examples of potential pollutants. After becoming contaminated with all or some of the potential contaminants mentioned above, potable water turns into wastewater [18].

Due to variables including climate change, population growth, water contamination, uneven water distribution, and industrial and agricultural operations, there is a greater need for available freshwater. For instance, agricultural activities use 70% of freshwater. The absence of freshwater forced individuals to develop alternative means of support. Given this, wastewater is a possible option for supplying water to sectors with high water demands, like agriculture. In numerous nations, the use of untreated wastewater for industrial, agricultural, aquifer recharge, and ecosystem restoration has a long history. Untreated wastewater has many benefits, like being a rich supply of nutrients and a cheap source of water, but it also contains chemicals that could be harmful to human health and the environment [12]. Agricultural productivity and local food production will fluctuate as a result of extreme weather events brought on by climate change, particularly in poor countries [10].

There will be 9.8 billion people on Earth in 2050, up from 7.6 billion in 2017, according to predictions. Due to the population's accelerating growth over the past few decades, urbanization has gotten worse. As a result, the production of municipal wastewater (MWW) has substantially increased. Since untreated wastewater discharge pollutes aquatic habitats and causes water-related diseases, the management of the enormous amount of MWW is a global concern [37]. Although wastewater reuse for irrigation has been extensively studied in the field, greenhouse, and laboratory, most of the research has focused on domestic and municipal wastewaters, with little work done on the reuse potential of complex mixed streams, which is the case in the majority of developing countries. The application of suspended growth biological processes for the treatment and reuse of mixed industrial, residential, and agricultural runoff wastewater for crop irrigation has not, as far as we are aware, been studied. [34.].

Only a small percentage of the earth's crust, which is mostly water, is appropriate for terrestrial living forms. Life is dependent on water. Only 2.5% of the total water resource in the hydrosphere is freshwater, and the majority of it is in the form of ice and permanent snow cover in the Antarctic and Arctic (68.7%). The amount of water that is accessible for human consumption is one of the initial justifications for the perception of water scarcity [6.]. It has already been suggested that treated wastewater effluent from irrigation systems could serve as a backup source of water for agriculture. Since a long time ago, no wastewater has been used for irrigation. Larger European communities started using wastewater for irrigation in what are known as "sewage farms" in the early 20th century [27].

The fast expansion of water pollution and growing concern over water availability have made the relationship between quantity and quality of water resources more obvious. In many parts of the world, freshwater resources are already scarce, and they are progressively degrading and getting more contaminated [30].

Countries are stepping up their efforts to improve the availability of food, and Agro-operations are geared toward achieving this objective. Only superb and efficient irrigation, which requires a lot of water, allows for year-round crop production. There are numerous difficulties with irrigation-based farming. The most pressing issue on the list is the present worldwide water shortage. [19]. It is not a novel idea to irrigate with effluent and poor-quality water; it has been done for centuries. Around 1700 BC, brick-conduits were used in Crete to convey sewage to fields so that it could be used to irrigate crops. The Romans started gathering pee from public restrooms and selling it to tanners and dyers from 600 BC. According to WWI, wastewater is produced all year long and supplies vital nutrients for agriculture production. In addition to giving plants nutrients, WWI has been linked to a number of additional advantages, including as lower fertilizer needs that result in higher yields without the use of excessive chemicals. Additionally, farm goods would be healthier and of higher quality with less chemical applications [37].

The United Nations defines water security. using water as a tactic to combat water stress and environmental protection issues. Access to water for productive purposes, environmental conservation, and disaster prevention are its main components. In this environment, water resources are used in a way that minimizes the waste of freshwater and allows wastewater to be recycled. Reclaimed water is used for agricultural purposes or artificial groundwater recharge when it is judged unfit for human use. In Nigeria, where there is a total of 39,200,000 hectares of arable land, sewage and freshwater resources were appropriated for agricultural use through the utilization of shaduf, canals, tanks, and other subirrigation systems. [4]. Reusing wastewater from domestic or industrial processes for irrigation is a common practice in most major industrial hubs across the world. For instance, Pakistani farmers have used wastewater to cultivate high-quality veggies. [20].

Reusing wastewater has developed into a crucial element of integrated water resources management (IWRM). Its importance cannot be overestimated as a result. According to various studies, WWR is significant in a variety of industries, including agriculture, industry, urban development, home reuse, potable water supply, and others [3].

2. RESEARCH METHOD

This work is a review paper. Journals, articles and previous project works relevant to the above-mentioned topic were carefully studied and sampled purposefully. Different works were studied and summarized to come up the information required for the preparation of the paper.

2.1 Type of data

Data used in this in this research is of secondary origin. Through review of papers, journal etc. This research was conducted using a meta-analysis.

3. RESULTS

Wastewater reuse has emerged as a practical option for pollution reduction when water reuse replaces effluent discharge to vulnerable surface water bodies, preserving and extending available water supplies. This is due to the difficulties associated with the discharge of untreated wastewater into the environment. Other benefits of reuse include lowering the amount of freshwater that is diverted from delicate ecosystems, replenishing soil nutrients in agriculture through irrigation, improving groundwater recharge, delaying the expansion of future water supply infrastructure, and creating or maintaining wetlands [2].

The outcomes show that the technical performance of the pilot integrated treatment system was successful in treating high-strength tannery wastewater, and that the treated effluent satisfies legal and acceptable international discharge standards. It may be possible to repurpose the cleaned effluent from the tannery for irrigation. Vegetable research revealed that Cr concentrations in field treated vegetables such tomato, cabbage, and carrot were marginally above WHO/FAO heavy metal standards. [5].

The results show that the high-strength tannery wastewater was successfully treated by the pilot integrated treatment system, and the treated effluent complies with acceptable national and international discharge criteria. The tannery's wastewater can be recycled for irrigation. Vegetable research revealed that Cr levels in field treated vegetables such tomato, cabbage, and carrot were marginally higher than the WHO/FAO heavy metal standards [10]. In order to deal with urban water limitations, cities compete with crop irrigation in rural areas. Along with population development, there will be an increase in the demand for biofuels and higher protein diets, which will result in a significant increase in agricultural output that can only be met by increasing water use in farming. By 2030, non-renewable groundwater withdrawals will increase by 66%, hastening the overexploitation of our freshwater resources, which will have an impact on millions of people by the end of the century and billions by the end of the century [23].

4. DISCUSSIONS

4.1. Water resources

Resources for water are sources of water that people may or may not use. Water is frequently used for agricultural, industrial, household, recreational, and environmental purposes. Almost all of these human uses require fresh water.

Fresh water makes up just 3% of the total amount of water on Earth, and slightly more than two-thirds of it is frozen in glaciers and polar ice caps. On Earth, saltwater makes up roughly 97 percent of the water. The majority of the remaining fresh water that hasn't frozen is found as groundwater, with only a small amount remaining above ground or in the air [29]. High biodiversity freshwater environments are currently decreasing more swiftly than those on land or at sea. When a mechanism for allocating water resources to users exists, it is referred to as having water rights.

A. Surface water

Surface water can be found in a freshwater wetland, lake, or river. Precipitation naturally replenishes surface water, and evaporation, subsurface seepage, and discharge to the seas naturally drain it.

Each surface water system's main natural source of input is precipitation from its watershed, but there are many additional factors that can affect how much water is present in a system at any one time. The capacity of lakes, marshes, and artificial reservoirs to hold water, as well as the permeability of the soil that lies beneath them, the features of the terrain that contribute to runoff in the watershed, the timing of precipitation, and regional evaporation rates are a few of these elements. Each of these factors also has an effect on how much water is lost [38].

Human activities can have major and perhaps disastrous effects on these variables. In order to increase storage capacity, humans typically construct reservoirs, and in order to decrease it, they drain wetlands. Humans routinely enhance runoff amounts and rates by paving areas and controlling stream flow. An important consideration is the total amount of water that is available at any given time. Some people who use water only sometimes need it.

B. Ground water

Subsurface water, commonly referred to as groundwater, is the fresh water that can be found in the cracks and crevices of rocks and soil. Water also flows through aquifers below the water table. It can be useful to distinguish between subsurface water that is closely related to surface water and deep subterranean water in an aquifer (sometimes referred to as "fossil water").

Subsurface water is treated in the same way as surface water in terms of inputs, outputs, and storage. The key differential is that because subterranean water has a sluggish rate of turnover compared to inputs, its storage capacity is often much greater than that of surface water. This distinction makes it possible for people to use underground water for a long time without experiencing any detrimental effects. However, the maximum amount of water that may reasonably be expected to be drawn from a subsurface water source over the long term is determined by the average rate of seepage above that source [14].

C. Desalination

Desalination now provides just a relatively small part of the total amount of water used by humans because it is more expensive than the bulk of other water sources. It is only economically viable for high-value usage in dry areas (such residential and industrial purposes). It is most frequently used in the Persian Gulf [36].

D. Frozen water

observing a Newfoundland iceberg Icebergs have been proposed as a supply of water in a variety of schemes, but up until now, this has only been done for show. Glacier discharge is thought to include surface water. One of the largest and harshest high-altitude regions on Earth, as well as the greatest area of permafrost and glaciers outside of the poles, may be found in the Himalayas, also referred to as "The Roof of the World." Ten of Asia's biggest rivers, which provide more than a billion people with a living, have their origins there [22]. Things are made more challenging by the fact that local temperatures are rising more quickly than the average global temperature. Nepal's temperature has only risen by 0.6 degrees in the last ten years, compared to a global warming increase of approximately 0.7 degrees over the previous 100 years.

E. Wastewater

Water reclamation is the process of transforming industrial or municipal effluent into water that can be reused for a variety of purposes (also known as wastewater reuse, water reuse, or water recycling). Reuse types include those in cities, agriculture (irrigation), the environment, industry, planned potable reuse, and de facto wastewater reuse (unplanned potable reuse). For instance, reuse can entail replenishing surface and groundwater supplies or irrigation of gardens and agricultural areas (i.e., groundwater recharge). Reused water can also be cleansed to satisfy drinking water standards and used to suit specific requirements in commercial, industrial, and residential settings (for example, toilet flushing). There is a long history of using treated municipal wastewater for irrigation, especially in desert areas. Reusing wastewater as part of sustainable water management will allow water to continue to be utilized as a substitute water supply for human activities [35]. This can reduce shortages and reduce demand for groundwater and other natural water sources.

Diverse technologies are employed to treat wastewater for reuse. These techniques can be coupled to meet demanding treatment standards and ensure that the treated water is pathogen-free or hygienically safe.

The Environmental Protection Agency (EPA) confirmed in 1992 the harmful effects on crops exposed to certain micronutrient offers in irrigation wastewater. The EPA increased the number of new and updated case studies, brand-new information on treatment and disinfection technologies, emerging chemicals and pathogens of concern, business economics, individual prices and financing options, public participation and approval, study tasks, and informational resources that are related to indirect drinkable reuse and commercial reuse problems in 2004. (EPA.2004).

The Environmental Protection Agency (EPA) and the United States agency for international development (USAID) updated the Standards for Wastewater Reuse in 2012. The main goal of the modification was to help make wastewater reuse better, based on a variety of global experiences. Updated assessments of regional variations in water reuse, improvements in wastewater treatment technology, the best ways to involve communities in project planning, international water reuse techniques, and elements supporting the expansion of risk-free and sustainable water reuse were all included in the 2012 standards. More than 300 professionals in the field of wastewater reuse contributed case studies, technical updates, and technical modifications. Based on good quality, the EPA and USAID (2012) suggested that irrigation water contain an ideal risk-free focal level of micronutrient offer. In fact, several nations around the world have created guidelines based on the standards established by the WHO, FAO, and EPA.

Between 2000 and 2006, more than 3300 wastewater treatment plants from around the world joined the AQUAREC worldwide initiative. The numerous wastewater treatment facilities were separated based on the various water treatment quality levels and use kinds, with agriculture serving as the main wastewater consumer. The largest number of reuse centers are in Japan and the Unified Species (1800 and 800, respectively), with Australia and the European Union following closely after with 450 and 230, respectively. In comparison to 50 in Latin America and 20 in Sub-Saharan Africa, the Mediterranean and Middle Eastern regions have about 100 wastewater treatment facilities.

10% of the world's irrigated land, or 20 million hectares, receive untreated or only partially treated effluent, according to the FAO. However, the projected wastewater-irrigated areas vary by country and by issues that have been addressed against those that have not, per [21]. 963 Mm3/year of untreated wastewater being used across the continent of Europe, according to [41] research on the amount of wastewater reused in agriculture. In Latin America, about 400 m3/s of raw wastewater are released and subsequently used to irrigate various crops.

4.2 Health risks related to Wastewater Reuse for Agriculture

Various places have different concentration levels, varieties of bacteria, and chemical compounds in wastewater, depending on local sanitary and socioeconomic conditions. According to [21], developing countries may have wastewater that is 10–1000 times more likely to have illnesses, protozoan bloodsuckers, and helminths than developed countries.

Table 1. Chemical and biological risks associated with the use of raw wastewater in agriculture. (Source, WHO)

Type of Risk		Pathogens
Biological	Bacteria	E. coli, Vibrio cholerae, Salmonella spp., Shigella spp.
	Helminths	Ascaris, Ancylostomiases, Tenia SPP
	Protozoans	Intestinal Giardia, Cryptosporidium, Entamoeba SPP.
	Virus	Hepatitis A and E, Adenovirus, Rotavirus, Norovirus
	Schistosoma	Blood-flukes
Chemical	Substance of sanitary interest	
	Heavy Metals	Arsenic, Cadmium, Mercury
	Hydrocarbons	Dioxins, Furans, PCBs
	Pesticides	Aldrin, DDT

According to [21]. persistent risk refers to the presence of chemical toxins that have an effect on human health over time, whereas acute risk refers to the probability of being ill temporarily after being exposed to low infectious doses of a pollutant. In addition, microbial disease can be spread by water both directly and indirectly (Table 2). Premature deaths globally have increased dramatically as a result of these disorders, particularly in developing nations.

4.3 Limitations Related to Wastewater Reuse for Agriculture

Whether the wastewater is treated or not, using it in agriculture has a negative impact on the environment, especially the soil. In the scientific literature, there is proof that soil's physicochemical qualities can alter. The most recent research has also identified fluctuations in the volume and content of soil's microbial biomass, as well as an uptick in microbial activity brought on by the reuse of agricultural wastewater. Due to insufficient wastewater irrigation, modifications in soil microbiology and physicochemical properties could endanger the long-term viability of the soil [6]. Assessments are made on the impacts of wastewater reuse in agriculture, as well as how these factors affect physicochemical variables like pH, organic matter, nutrients, salinity, and pollutants, as well as microbial diversity. Numerous research has been conducted on the impacts of wastewater on soil, some of which are listed in Table 3.

Variations in soil pH caused by irrigation with effluents from municipal wastewater treatment plants at various levels of treatment have been recorded in numerous research investigations (initial, main and additional). Additional elements that affect soil pH include the type of soil cover, the soil's texture, and the duration of irrigation [6.]. Changes in soil pH have an effect on the availability of nutrients and steels, the cation exchange capacity (CEC), and the mineralization of organic matter.

Some scientists believe that pH occurrence is an important component in defining the variety of types and selection of soil microorganisms since an increase in free steels is unrelated to changes in soil pH and has the capacity to impact the substrate of the microbial communities. [11].

Organic matter is also necessary for the soil's structure and ability to store vitamins and minerals. The soil's ability to hold onto water is increased by the organic matter, which also impacts how water drains from residential buildings and how well they can withstand compaction. This occurs as a result of aggregates' expansion and stability (sand, lime, and clay). Additionally, organic matter increases the cation exchange capacity (CEC) and, as a result, the fertility of the soil by contributing important macro- and micronutrients (N, P, and S) for plant growth [31]. Depending on the amount of organic matter present, numerous studies (see Table 4) have shown an increase in total organic carbon (TOC) and nitrogen (N) in those soils watered with domestic wastewater. The availability of organic materials also increases as a result of this experience. Therefore, the presence of specific bacterial communities in the soil may be favorable. Between 40% and 70% of soil bacteria are linked to stable aggregates like clay particles [33].

Table 2. The influence of wastewater reuse for agricultural on the soil's parameters (physicochemical and microbiological)

Parameters	Related Effects on the Soil as well as the Environment	
	Physiochemical	**Microbiological**
PH	increases the availability of nutrients and metals. Mineralization of organic matter Improves the cation exchange capacity	Increases the richness. and diversity of the microbial community
OM (organic matter)	Soil structure stabilization Formation of aggregates Water retention Improves nutrient content Buffer Capacity Cation exchange capacity Enzymatic activity Increase in TOC Increases the availability of contaminants	Selection of specific populations and soil microhabitats
Nutrients	Increase in organic soil matter	Perturbation of the metabolic

	Water retention Leaching to groundwater Improves nutrient content. Risk of eutrophication of aquatic environments	activity of microbial soil communities
Salinity	Decreased stability of aggregates Changes in soil structure in the long term Permeability of soil and water retention Increased soil compaction Variation in soil pH Negative impact on soil fertility Dynamics in organic and inorganic compounds Heavy metal leaching	Changes in soil microhabitats and variation in the richness and diversity of the microbial community.
Contaminants	Soil toxicity and leaching Accumulation in soils Negative impact on soil fertility Potential contamination of the food chain Mineralization of organic matter Changes in enzyme activity Decomposition of fallen leaves Limiting soil fertility	Increased tolerance to microbial contaminants. Antimicrobial resistance. Reduction of microbial biomass and changes in its structure

The concentration levels, the composition of the organic matter, and the soil texture all affect the stability of the aggregates in the soil as well as the ability of the organic matter introduced by wastewater irrigation to retain water. Therefore, irrigating sandy-clay dirt with wastewater improves the security of its aggregates. As an alternative, aggregate security is reduced by soil with a clayey texture. Additionally, using wastewater for long-term irrigation (more than twenty years) might cause detrimental changes in soil structure because to the accumulation of sodium in the commercial complex. A study on sugarcane that was watered with treated wastewater for a year discovered an increase in the amount of organic matter in the soil, which, according to the authors, preferred the reuse of wastewater in the research areas [40].

Numerous studies have noted an increase in the various forms of nitrogen (N-NO3, NH4-N, or Complete N) following irrigation with wastewater for times ranging from one to twenty years (Table 3). However, soil microbial regions might be affected, especially the activities related to the cycle of these elements, despite current advantages in agricultural production and a decrease in chemical representations (plant meals) from the increase in N and P added by wastewater.

More than 90% of the nitrogen in the soil is still present in organic matter. The main forms of absorption by plants are ammonium and nitrate, along with some organic nitrogen compounds. Since very small levels of nitrite may have toxic effects on plant development, it is generally believed that nitrite is an intermediate product in the conversion of ammonium to nitrate in the soil. These complex organic nitrogen intermediate products can be soaked. Organic nitrogen fertilization can impact the quality of the grown product as well as the strategy's metabolism [25]. Likewise, vegetables can accumulate large levels of nitrate that, when consumed by living things, provide significant health hazards when nitrogen is applied excessively (via fertilizer, sewage, or other sources).

The accumulation of inorganic N in the soil, which may affect the biodegradation of carbon-containing compounds, is another effect. Additionally, an excessive supply of nutrients in the soil may not be beneficial. Runoff can contain nutrients like phosphorus and nitrate, which can then leak into the groundwater and cause eutrophication or poisoning of other environments [7].

Soil salinization (an increase in the content of soluble salts) or sodification can be promoted by irrigation wastewater (an unwanted of compatible sodium in connection with various other cations). Salinity problems occur when the soluble salts concentrate in the root zone, resulting in osmotic stress that limits the ability of plants to absorb water and nutrients.

Therefore, solidity has a negative impact on the stability of aggregates and soil structure because a high compatible salt content causes a reduction in permeability. Due to the destruction of aggregates caused by high Na+ concentrations, sodicity is caused by widespread and dispersive processes on clays [24]. Numerous studies have noted that changes in sodicity increase soil compaction while decreasing the rate at which water infiltrates the ground. Variations in soil salinity or sodicity thus harm the soil microbiota. Results on microbiological areas are primarily related to changes in soil structure and also osmotic potential reductions [8].

Another study assessed the effects of salinity on the composition, function, and habitat of soil microorganisms. According to their findings, soil bacteria are metabolically stressed and anxious by higher salinity web content. Additionally, the biomass's Carbon-Nitrogen connection tends to decrease as soil salinity increases, demonstrating the dominance of bacteria in the soil's microbial biomass.

The disposal of toxins (metals and pharmaceutical chemicals, for example) through other media, such as wastewater, which accumulate in the soil as a result of irrigation, also contributes to soil deterioration. Normal soil steel concentrations depend mostly on the adult product (rock) and can exist at levels that are safe for living things to ingest without being subjected to anthropogenic chores. However, population growth and industrialization have increased the presence of these polluting agents in wastewater and, consequently, in irrigated soils. The most likely contaminants that have accumulated in soil as a result of wastewater irrigation include metals like Fe, Cr, Zn, Pb, Ni, Cd, and even Cu, which are abundant in wastewater. The presence of these elements in the soil can reduce fertility and/or alter soil microbial communities [6]. They can also affect a soil's phytotoxicity, which can have an impact on plant growth and contamination. Other ecological community processes harmed by steel contamination include the mineralization of organic materials, changes in soil enzyme activity, the decomposition of waste, a decrease in microbial biomass, and also adjustments to microbial structure.

Additionally, the metals accumulated in a soil can interact with pharmaceuticals or other ECs, thereby worsening the effects on the soil. Numerous studies have also noted strong correlations between the presence of metals in soil and the development of antibiotic resistance in certain ecological situations [16]. The fate and effects of these substances (arising metals and/or contaminating representatives) depend on a variety of factors, including the chemical properties of the pollutant type, the types and age of the vegetation cover, the composition of the rhizosphere microorganisms, and soil characteristics (temperature level, pH of the dietary atmosphere, soil texture and also structure). According to some scientists, low-mobility compounds accumulate in soil with irrigation periods of one to 100 years, while high-mobility substances do not [39]. Additionally, scientists from all over the world have emphasized the dangers posed by high-mobility chemicals, given the potential leaching that might damage groundwater resources. For instance, it was shown that high-mobility compounds polluted the groundwater of agricultural areas that were irrigated with wastewater in several amoxicillin-degradation products. Another study concluded that ibuprofen has a high potential to permeate through soil and damage groundwater resources after detecting reduced retention rates for the drug in soils.

4.4 Wastewater reuse and environmental sustainability

It can be advantageous for the environment, society, and economy to reuse cleaned wastewater. According to the Blueprint, water reuse can benefit the ecosystem qualitatively and quantitatively by easing pressure from UWWTP discharge on sensitive areas by substituting abstraction. Reusing water often results in lower energy and investment costs than other water supply techniques like desalination or water transfer, which also reduces greenhouse gas emissions [15]. Reusing treated wastewater can be seen as a dependable source of water that can handle peaks in water demand and is unaffected by seasonal drought and weather changes. This can benefit agricultural operations that rely on a reliable water supply during the irrigation season, reducing the likelihood of crop failure and the ensuing financial losses. By lowering the need for additional fertilizers, an accurate assessment of the nutrients in treated wastewater may also benefit farmers and wastewater treatment. Significant environmental advantages of wastewater reuse are a primary driver of the practice. However, if it is not well planned, the reuse of wastewater can pose major threats to both the natural and human environments [26.].

In addition to the benefits associated with improved water availability for irrigation, urban water reuse projects can have substantial environmental consequences because they help to improve the water quality of receiving bodies of water by diverting effluent from their release. This is an illustration of a situation that benefits everyone involved, the environment, and the urban and agricultural sectors [22]. Reusing water helps populations become less reliant on groundwater and surface water supplies and can reduce the quantity of water that is taken away from fragile ecosystems. The amount of nutrients that wastewater dumps into waterways may be reduced or even eliminated by reusing water. It is also possible to replenish previously destroyed water supplies that have run out of water by using this "new" water source.

Another strategy to release freshwater for domestic use and improve the quality of river waters used to draw drinking water is to reuse treated wastewater for agricultural and industrial applications [13].

4.5 Renewable energy Resources in Water and Wastewater Treatment

Water supply applications have long made use of renewable energy technology. They can be used for water-treatment systems as well as to pump water from wells or to power booster pumps. Both established and emerging methods for the treatment of water can be powered by renewable energy sources (UV disinfection, desalination plants, and purification, straight warm, or photocatalytic oxidation to ruin pathogens).

Renewable energy alternatives for water supply and wastewater treatment, such as solar, wind, biomass, and biofuel-related resources, are becoming more and more enticing. Water and wastewater management can be done using solar energy directly or indirectly (thermally or electrically).

The best uses of solar thermal energy include pasteurization, a variety of purification processes, desalination of salted or brackish water, and indirect uses such water pumping. Electricity from solar panels is among the simplest technologies to use to pump water. PV is suitable for powering UV systems, RO and ED systems in desalination facilities, among other applications. In particular, solar energy is essential for handling wastewater. For wastewater treatment, direct sun radiation is used. Another effective option is solar detoxification, which combines chemical and organic treatment. Chemicals are used to increase the treatment's effectiveness. TiO2, also known as hydroxyl extreme, is an efficient oxidizing agent that can attack almost any sort of organic material and is used as a catalytic treatment in solar wastewater detoxification.

Similar to this, wind energy can be used to either mechanically pump water (using windmills) or use the electricity produced by the wind turbine to pump, treat, or purify water. Compared to electrical wind turbines, mechanical wind pumps (windmills) operate at lower wind speeds. Electric wind turbines need a normal wind speed of 5 to 6 m/s to be competitive with windmills for water pumping applications. Windmills start pumping at speeds between 2.5 and 3.5 m/s. However, as the size of the wind turbine blades increases, the initial wind speed increases. On the other hand, because they are more convenient and produce power, electric wind turbines have a lot of advantages over windmills. The turbine can be positioned at a higher wind speed, and the pumping site can be linked with the power produced. Batteries or water filtration devices can be powered by the electricity generated by the turbine. Water pumping, lighting, and water filtering systems (such UV (lamp-driven) and desalination systems) are a few applications for wind turbines.

In rural towns, biogas can also be used to power water pumps. Methane, the biogas produced by biomass digesters, is also excellent for lighting and food preparation in addition to being used as a fuel for water pumping. The other widely used biogas is ethanol, which is becoming more popular for refueling automobiles. Biofuels are a tried-and-true innovation that can save up to 80% of the gas needed by a diesel engine. The development of SMBs that can use any form of agricultural deposits to produce power or thermal heat is a new biomass breakthrough. This invention can supply all of the power needs of small to medium-sized cities and urban amenities, including water pumps and water filtration systems. This technology can currently produce up to 100 kW of power and will eventually be available in large capacities (see Phase 3 for more recommendation). Additionally, hybrid systems are becoming more desirable today, especially for independent distant applications.

A hybrid system may include a combination of solar panels, wind turbines with or without backup generators, and battery storage. However, when promoting any form of renewable energy innovation for water treatment in small towns, one must take into account issues like system sustainability, costs, the availability of power supplies, skilled labor, and cost-effective components. It can be quite expensive to use renewable energy technology for water treatment, especially desalination plants. The process consumes a lot of energy, which is an expensive investment, especially for rural applications. On the other hand, for some medical needs and regions, renewable energy sources may be more feasible options. For instance, due to rapid grid expansion, grid power may not be a viable source for isolated regions of many developing nations and islands. Renewable energy sources may be the best choices in such circumstances. Every decision-making mechanism must therefore be evaluated in light of neighborhood issues and system sustainability issues.

5. CONCLUSION

Agriculture is a large consumer of wastewater globally. It is believed that finding suitable irrigation resources is crucial for protecting natural water bodies and ensuring food safety. The safe use of wastewater as an alternative source of irrigation is a recognized strategy for making the best use of available resources and avoiding water pollution. This strategy is becoming more and more important globally, especially in countries where there is a shortage of fresh water. However, there are risks associated with this type of use that need to be weighed against a local infrastructure, taking into account soil as a receiving atmosphere and ensuring pollutants won't be transferred from one tool to another (water to soil). Quantitative risk analysis should be the focus of national initiatives. This would enable a lot more effective and targeted management taking into consideration that agricultural reuse can result in a very real public health issue if the risk is not considered. The risks of wastewater reuse in farming are significant, ranging from effects on human health to changes to the physicochemical and microbiological residential or commercial properties of dirt. The search for suitable irrigation resources, such as the reusing of untreated or badly treated wastewater, could result in preventable danger factors under adverse financial situations. In order to encourage the extensive use of wastewater in farming, it is necessary to consider both the positive aspects of this exercise as well as the negative effects and numerous low-cost methods. The missing component that is required for the proper use of agricultural reuse is a quantitative assessment of microbiological hazard that describes the concentration of helminths. Because of the nascent growth of standards and the requirements of some countries that do not adhere to international standards, this shortage has actually promoted the use of raw sewage water. In order to eliminate subjectivity and progress the safe reuse of recurrent water, the renovation of the helminth finding method should be the next milestone.

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