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Assessing the Efficacy of Treated Water when Utilized in Eco-Cities, as Well as the Effectiveness of Different Natural Materials in Recovering and Eliminating Phosphates from Wastewater

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Abstract: One of the main factors contributing to the decline in water quality is eutrophication brought on by excessive phosphorus (P) loading. This study looked at the removal and recovery of P using 12 different materials, including four different types of calcite, wollastonite, dolomite, hydroxyapatite, eggshells, coral sands, biochar, and activated carbon. A series of batch tests using synthetic wastewater solutions containing 10-100 mg PO4-P/L were used to achieve this. The lab houses large-scale, calcite-based column filter experiments that were established using the findings of this investigation. For 64 days, routine wastewater samples of influent and effluent were taken. Changes in pH, percent decrease, and the amount of P adsorbed were all used as performance indicators for filters.

P removal and recovery differed among treatments and media in the batch experiments. The minerals calcite, wollastonite, and hydroxylapatite performed the best. Additionally, coral sands, activated carbon, and eggshells decreased and absorb P. The lowest P reductions and adsorption rates were found in the remaining materials. The rates of P removal and adsorption by the three column filters were comparable. Over a 4-hour hydraulic retention time, the columns attained an average P decrease of 12.53% and an average P adsorption of 0.649 mg PO4-P/ kg medium.

After 31 days for two of the columns and 36 days for the third, saturation was attained. The pH of the effluent was consistently buffered by the filter material to between 6.0 and 7.0, with no signs of buffer capacity degrading after saturation. No P species could be found in the filter media's crystalline structure using XRD analysis. This study provides knowledge on the performance of massive column filters functioning in sophisticated, ecologically engineered wastewater treatment systems, as well as insight into how the chosen media behave during P removal and recovery programs.

Keywords: phosphorus recovery, calcite, wollastonite, dolomite, eggshells, wastewater

1. Introduction

Phosphorus (P) is a vital element required for the survival of bacteria, plants, and other living things. Animals need phosphorus to create their bones and teeth, whereas plants need more phosphorus to maintain cellular growth, perform photosynthesis, and produce fruit and seeds that are viable [1], [2]. This component is also essential for the biological processes that result in complex molecules. Energy is released when P switches between adenosine diphosphate and adenosine triphosphate, which is what drives energy production. Phosphodiesters, the backbone connecting one nucleotide to the next, are also present in the polynucleotide structures of DNA and RNA[3].

Despite not being scarce in nature, phosphorus is frequently a limiting nutrient, particularly in freshwater aquatic habitats. P is the thirteenth most abundant element by mass in saltwater and the eleventh most abundant element in the lithosphere [4]. Due to the global P cycle's characteristics—a rapid P cycling stage followed by an incredibly slow stage—the element is limiting. Before being buried in aquatic sediments or transmitted into the soil, P flows fast through the biotic section of an ecosystem. The processes that carry P through the soil or aquatic sediments, however, are very slow [5].

P can contribute to nutrient contamination, also known as eutrophication, when it is present in high amounts in water bodies. Discharges from point sources, such wastewater treatment facilities, and non-point sources, like agricultural and urban runoff, are examples of anthropogenic sources of phosphorus (P) to aquatic bodies [6], [7]. Since nutrient pollution promotes the quick growth of both plant and microbial biomass, it has considerable negative effects on aquatic ecosystems. The rapid development may reduce dissolved oxygen levels, resulting in hypoxic or anoxic conditions in the water body, decreased transparency, and changes in the composition of the natural community. This has a cascading impact. Since the visual and recreational features of the water body may be affected as well as its appropriateness for industrial usage and fisheries, eutrophication has major negative economic effects [8]. Unpleasant taste, odor, or coloring of the water is examples of aesthetic and recreational concerns. Eutrophic conditions may also have more severe effects, such as a community shift toward cyanobacteria species, some of which have toxins that can be harmful to domesticated animals and people [8], [9]

Eutrophication has been characterized as a serious concern that requires attention because of the harm that nutrient pollution causes to natural communities and the ramifications for manmade populations. Eutrophication brought on by excessive P loading has been identified by the United States Environmental Protection Agency (EPA) as a major factor in the decline of freshwater quality in the country [10]. Eutrophication is thought to be the cause of pollution in over 60% of the country's impaired rivers and about 50% of its impaired lake

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regions. The EPA's strategy for combating eutrophication is predicated on the notion that if the ecosystem's important limiting nutrient—often P in freshwater—is regulated, then the rapid development of algae and the eutrophication's cascade impacts may be avoided. Because eutrophication is caused by a variety of variables, this technique offers an oversimplified answer [11]. Because local factors including climate, nutrient loading, anthropogenic inputs, historical inputs, and geologic conditions all have a substantial impact, there is no single critical threshold for a P content in a water body that, if exceeded, will result in eutrophic conditions [12] [26].

By reducing the demand for minable P, phosphorus recovery from wastewater effluent has emerged as an approach that can help minimize the negative effects of eutrophication and turn P from a finite resource into a more renewable resource. Filters containing P-adsorbing medium have been added to build wetlands and wastewater treatment systems as one application of this method. For these reasons, a wide range of filter materials have been studied, and they can typically be divided into three groups: natural materials, industrial byproducts, and man-made items [13]. Through batch research or column experiments, these materials have been evaluated for their capacity to lower P concentrations and adsorb P from wastewater. Numerous minerals, organic-based materials (such peat and biochar), marine sands, and shells are examples of natural materials that have been examined [14] [28]. Steel slag and oil-shale ash are two industrial byproducts that have been effective at removing P from wastewater. Finally, the tested man-made items are largely several kinds of light-weight aggregates and 12 nanoparticles [15].

Because they include a lot of aluminum (Al), calcium (Ca), or iron, these compounds are effective for extracting and adsorbing phosphorus (P) from wastewater (Fe). It has been demonstrated that calcium-based materials can recover phosphorus through the mechanisms of calcium-phosphate adsorption and precipitation, frequently as the mineral hydroxylapatite [16].

When building filters to extract and recover P from wastewater, the destiny of the media after saturation is a crucial factor. In addition, it has been demonstrated that P bound to Ca is more bioavailable than when it is bound to Al or Fe, making Ca-based materials of greater interest for recycling. Some saturated Medias can be recycled for agricultural use if they are non-toxic, pathogen-free, and capable of desorbing P to release it back into the environment. It was noted that amendments did add some P to the soil as well as other micro- and macronutrients and raised the pH of the soil. Long-term13 benefits of large-scale soil amendments may become increasingly apparent, according to researchers' hypotheses, since the need for regular applications of traditional P fertilizers may decline due to the slow release of P from saturated filter medium.

2. Literature Review

Water represents an important and necessary resource for the establishment of eco-cities, and its renewal is a more important matter. Therefore, the location of the city must be chosen in accordance with these two conditions, the availability of water and ensuring its renewal, in addition to a set of factors that must be available to ensure the continuity of the city such as

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climate, agriculture, social relations and age groups, which can be summarized in the figure (1).

It is clear from experience that it is effective in desalinating brackish water that can be extracted from the ground, which makes it of importance to the possibility of establishing cities in remote areas where groundwater is available with salinity and which is difficult to supply with potable water networks. Groundwater sources with new water is extremely important to ensure the flow of groundwater, so eco-cities become the best urban patterns in this case, as agriculture is one of the most important sources of groundwater supply with high water rates, which is achieved in the components of eco-cities that produce food themselves by cultivating their urban surroundings or even the buildings themselves[17] [14].

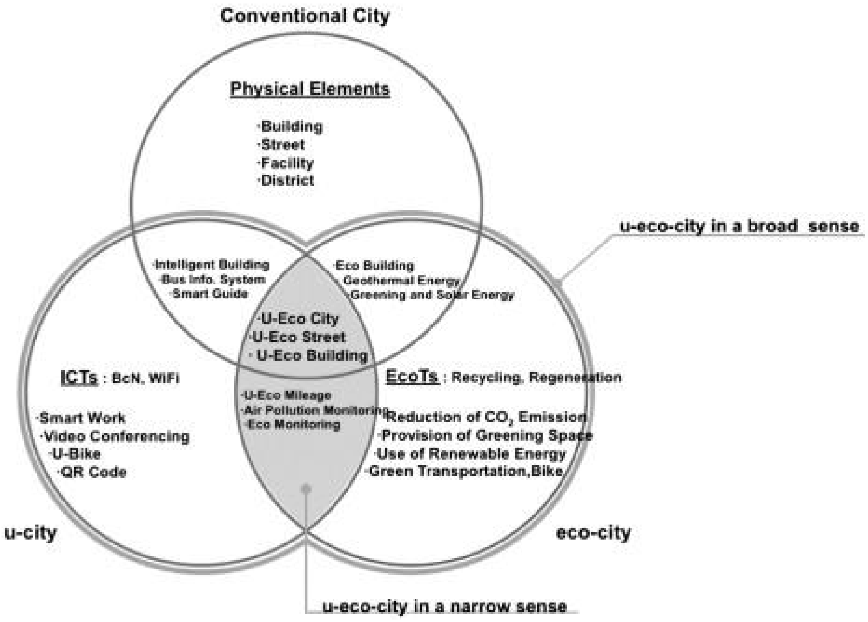

Figure (1): Relation between u-city and eco-city in the context of u-eco-city.

3. Material And Methods

Any physical, chemical, or biological alteration to the quality of water that has an adverse effect on living things or renders the water unsuited for intended usage is referred to as pollution. as you are aware of the contaminants

The United Nations Environment Program defines it as any physical, chemical, organic, or radioactive substance that is present in wastewater that lowers the water's quality while also posing a risk that may be avoided.

- Physical change: This word refers to alterations in a substance's characteristics, such as color, taste, odor, electrical conductivity, hardness, temperature, turbidity, and suspended particles.
- Biological detection: involves the type and quantity of microorganisms that can exist in it, such as bacteria, parasites, fungi, and viruses.
- Chemical modification: the types and quantities of minerals, electrolytes, salts, pH, alkalinity, and other chemical qualities, as well as radiological, are all examples of chemical alteration.

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Industrial wastewater is a harmful source of pollution for both the environment and public health since it comprises a variety of physical, chemical, and biological "vitality" pollutants.

Preparation of the absorbent media:

***Preparation of* Calcite**

$CaCO_3$ is the chemical formula for the calcium-carbonate mineral calcite. Three mines in Egypt were the sources of the samples. This material, which had an average particle size range of 25.4-44.5 mm, was taken from heaps of exposed crushed calcite. After being crushed and sieved, this material produced an average particle size range of roughly 4-9.4 mm. The following calcite sample (Cal-SW) was taken from a quarry of the mineral. This material, which had an average particle size range of roughly 9.5-11.1 mm, was taken from heaps of exposed crushed calcite.

In order to remove any fine particulate matter that was adhered to the outside of the media, these materials were prepared by being repeatedly rinsed in distilled deionized (DDI) water until the rinse water was visibly clear. These materials were then placed in a drying oven at about 105°C overnight to dry. Cal-SH was then made using a different technique (Cal-SH UR), in which it was not rinsed or left to dry overnight because preliminary tests revealed that heating this media significantly reduced its performance.

In the initial tests, there was no discernible difference in performance19 between material that had been rinsed or not and had not been dried at 105°C. A calcite quarry in Florence, Vermont provided the final calcite supply (Cal-OM). This was a powdered byproduct of mine tailings with an average particle size of 0.045 mm.

Preparation of Wollastonite

$CaSiO_3$ is the chemical formula for the calcium-silicate mineral wollastonite. This substance was a mine tailings byproduct in powder form. This media's typical particle size was about 0.4 millimeters.

Preparation of Dolomite

$CaMg(CO_3)_2$ is the chemical formula for the calcium-magnesium carbonate mineral known as dolomite). The average particle size of this substance was between 6.4 and 9.5 mm. The material was periodically rinsed in DDI water until the rinse water was clearly clear, and then it was put in a drying oven at about 105°C overnight to remove any fine particle matter adhered to the outside of the media.

Preparation of Hydroxylapatite

Calcium-phosphate mineral hydroxylapatite has the chemical formula $Ca_5(PO4)_3(OH)$. Due to its mineralogical resemblance to hydroxylapatite, a pelletized rock phosphate fertilizer, the average particle size of this substance ranged from 1 to 5 mm.

Preparation of Egg Shells

At a nearby shop, two dozen white Grades-A chicken eggs (Egg) were purchased. The egg's edible section was cut off, and the shells were cleaned under running water before being dried at 22°C. After that, to form a low-oxygen chamber, the dried shells were put in a disposable aluminum pan and covered with heavy-duty aluminum foil. This package was set directly on the embers of a wood burner at 300°C, and it cooled over the course of eight hours to 22°C. After being crushed, the shells produced particles with an average size of 5 mm.

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Preparation of Inactivated Biochar and Granular Activated Carbon

Granular activated carbon (GAC) and inactivated charcoal (FOX) were purchased from Egyptian sources. GAC was a type of activated carbon made from bituminous coal that was aquarium-grade and heat activated. These materials were cleaned by rinsing them in DDI water many times until the rinse water was clearly visible. These materials were then cooked on a stirring hotplate set to 90°C for 1 h in DDI water at a ratio of 1 L per 100 g of media, and dried for 48 h at 22°C.

Preparation of Coral Sands

We bought two different kinds of coral sands from a nearby merchant. The first was coarse marine coral sand made of aragonite. To achieve an average particle size range of 2.5–5.5 mm, this material was crushed and sieved. The second was fine mined aragonite sea coral sand that had been heat sterilized. The typical particle size was in the range of 0.1-0.75 mm. The two 21 of these materials were dried for 24 hours at 22°C after being regularly rinsed in DDI water until the rinse water was clearly clear.

Table (1) The most important pollutants in wastewater

Contaminants	Their importance
Suspended material	Increased protector deposits create anaerobic conditions in the water as it discharges
For Nutrients	like nitrogen, phosphates, and it causes unwanted water organisms to grow
Highly Important Pollutants	Organic and inorganic compounds are carcinogenic and highly toxic.
Organic materials are difficult	materials that are capable of resisting conventional treatment methods such as industrial detergents and decomposing phenols
Heavy metals	Industrial process damage products
Inorganic soluble salts	Sodium salts), calcium, sulfate

Test procedure

To assess the efficiency of different media types in removing soluble reactive phosphate (SRP) from synthetic wastewater and to establish the SRP adsorption capacities, batch tests were conducted. For this investigation, KH_2PO_4 was dissolved in DDI water to form synthetic wastewater, which was then prepared to initial SRP concentrations of 10, 25, 50, 75, and 100 mg PO4-P/L. For 24 hours at about 22°C, 1.0 g of each media was combined with 25 ml of each wastewater solution and put on a shaking table set at 200 rpm. The analysis comprised standards and controls. In either three or five duplicates, each treatment was performed. Following individual analysis of each repeat, the treatment replicates were averaged and used in the studies. All samples were immediately run through 0.45 m filters after the 24-hour shaking, and the residual SRP concentration was determined.

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Methods of using treated water in ecological cities

Most of the world's nations have shifted toward planning and sound integrated management to reuse industrial wastewater once it has been sufficiently and effectively treated to prevent damage from re use, replacing the outdated approach of draining it into bodies of water.

The development of Bram Integrated environmental monitoring of pollutants and their effects on the surrounding environment is necessary to ensure environmental protection, as it is essential to the success of water treatment and reuse. As a preliminary stage, classification of effluents aids in the following step is to prepare preliminary environmental studies and to make a list of the pollutants that are anticipated to be present in the facility. It is crucial to environmental management since it aids in choosing the appropriate amounts and techniques of treatment activities.

The kind and proportions of these pollutants will determine the control and treatment technique to be used. Prepare designs of the best fusion of approaches to determine methods, procedures, and levels of processing.

Environmentally compatible waste:

Waste that can be removed or disposed of using the required water treatment processes, taking into consideration the fact that different industries have different waste concentrations, The first stage of treatment typically entails coarse clarification and sedimentation, followed by sludge treatment activators and filters. It may also contain additional aerobic biological processes designed to oxidize and destroy most of the organic waste. Measured and typically stated in terms of extent, treatment success the effectiveness of treatment methods in lowering values for biological oxygen absorbed and chemical oxygen consumer.

Environmentally incompatible waste:

Numerous pollutants in the liquid waste make it incompatible with earlier treatment techniques.

Because it impairs the biological treatment's processes of action by including poisonous elements like cyanide, heavy metals, petroleum oils, and greases that restrict or eradicate the organisms that carry out the biological process. Low amounts of these residues do not interfere with or hinder the treatment process; instead, they pass through the treatment plant unaffected along with the prior contaminants. Hazardous substances including acidic waste, combustible materials explosion, and thick or viscous substances that may cause blockages are absolutely forbidden from entering the sewage network.

Wastewater treatment methods:

Pollutants are removed from the environment and industrial wastewater is treated using a variety of techniques. Treatment modalities can be classified as physical, chemical, standalone, or a combination of all three. These technologies include a combination of conventional technologies (bio-treatment), ion exchange technology, microfiltration technology (MF), ultrafiltration technology (UF), reverse osmosis technology (RO), and nanofiltration technology. Wastewater generated in the petrochemical industry is treated to be reused again in steam production, in processes, or to replace water quantities (NF). There are still significant amounts of sludge and putty materials, which are buried in specialized landfills, as thermal energy is utilized to vaporize some of the water, condense, and discharge

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as pure distilled water, crystals, which does not result in any wastewater (water industrial waste) (ZLD).

Physical or mechanical treatment methods:

Numerous procedures are still utilized in wastewater treatment; however, the following are the most crucial ones: Filtering, coagulation, sedimentation, filtration, and flotation Processes for oil clarity, separation, and aeration are necessary for biological treatment

Chemical treatment methods

The most popular chemical procedures in this area are precipitation and adsorption. Chemical treatment methods for industrial wastewater include the addition of chemicals to the occurrence of chemical reactions in order to get rid of or convert pollutants into compounds that are easy to separate.

Most of the time, chemical precipitation is accomplished by creating a chemical precipitate. Both components that may separate during sedimentation and components that have reacted with chemical additions are included in this precipitate. As intended, adsorption relies on the attraction between bodies to remove certain substances by their adhesion to the surface of solids. Chemical procedures are used to introduce scale-preventing compounds and modify the pH value. processing techniques including oxidation, precipitation, and others are used to get rid of harmful compounds and heavy metals. Physical therapies are administered in conjunction with chemotherapy, and some biological therapeutic approaches may also be necessary

Biological treatment methods

Biological treatment procedures in order to remove pollutants. This process involves turning pollutants into gases that escape to the atmosphere or into clumps of living things (sludge), which can be removed via sedimentation, as well as for the removal of nutrients (nitrogen and phosphorus).

The last sedimentation tanks' settled sludge is transferred back to the aeration tanks. To be the medium created by the organic oxidation process, and continual stirring is considered to stop oxidation from happening There is no sedimentation inside the basin out of concern that it may build up and lessen the effectiveness of the oxidation and revitalization process.

Except for trace amounts of suspended matter and low BOD levels, anaerobic bacteria in the sedimentation zone, sedimentation basins, and biological treatment units remove all oxidized suspended materials before the water exits these processes.

The biological treatment process can be either aerobic or anaerobic, and it involves a variety of different processes. One or more of these processes can be used in the treatment facility. Air must be added to an aerobic biological treatment process either directly using pistons or air diffusers, indirectly via mechanical aerators, or both. To preserve the life of the microorganisms required for biological treatment operations, you also need to change the pH value and temperature. it also need to make sure they have access to nutrients, ventilation, and enough oxygen intake. Additionally, biological treatment facilities must be controlled with care.

Due to the chance that some substances or compounds may be hazardous to the bacteria utilized in processing operations, it may be risky to use microorganisms to digest

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contaminants. There must be some preliminary physical and/or chemical treatment techniques used.

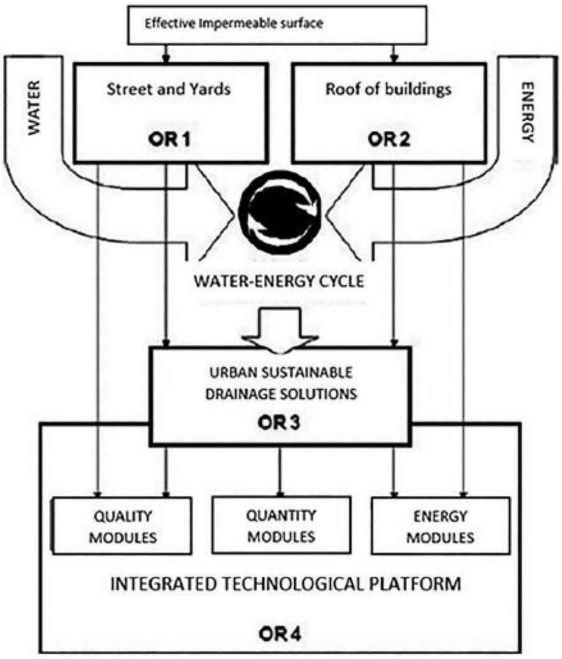

Figure (2) The working principle of the G.I.A.R.E project (from www.giare.eu, 2019).

Street cleaning with treated water:

Reuse of wastewater after treatment for useful purposes, such as: agricultural irrigation, green landscaping, industrial operations, construction, and others, as water recycling gives an abundance of resources and money**.**

With the help of a decision analysis and suggested environmental and financial evaluation criteria, it is possible to choose a cleaning scenario for a particular area.

• The results of the computations are shown in Table 3, and Scen2 with sweeping and one-day street washing is the most frequently chosen option.

• Scen4, which involves sweeping and washing the street over the course of five days, is chosen as the most advantageous option eight times (two of those times occurred when the weight of the cost criterion was decreased in comparison to environmental criteria), allowing us to draw the conclusion that costs should always be considered and calculated when choosing and analyzing cleaning strategies.

It can be said that, by weighing the economic and ecological effects, a scenario that allows for the observance of the principles of sustainable development is chosen. Scenarios such as Scen1 (sweeping only) and Scen4 (where the cleaning and washing process is the longest 5-day process) are frequently chosen as the least desirable options.

By using the exponent in the formula, this strategy allows for the potential of further weighting the criterion (2). The additional weighting of each deviation from the ideal point according to its value is made possible by this exponent. The importance of significant departures from the ideal point by the approach increases with the size of the value of.

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Scenario 2 is always chosen as the most advantageous one for determining the Effectiveness of Street Cleaning with the Use of Decision Analysis

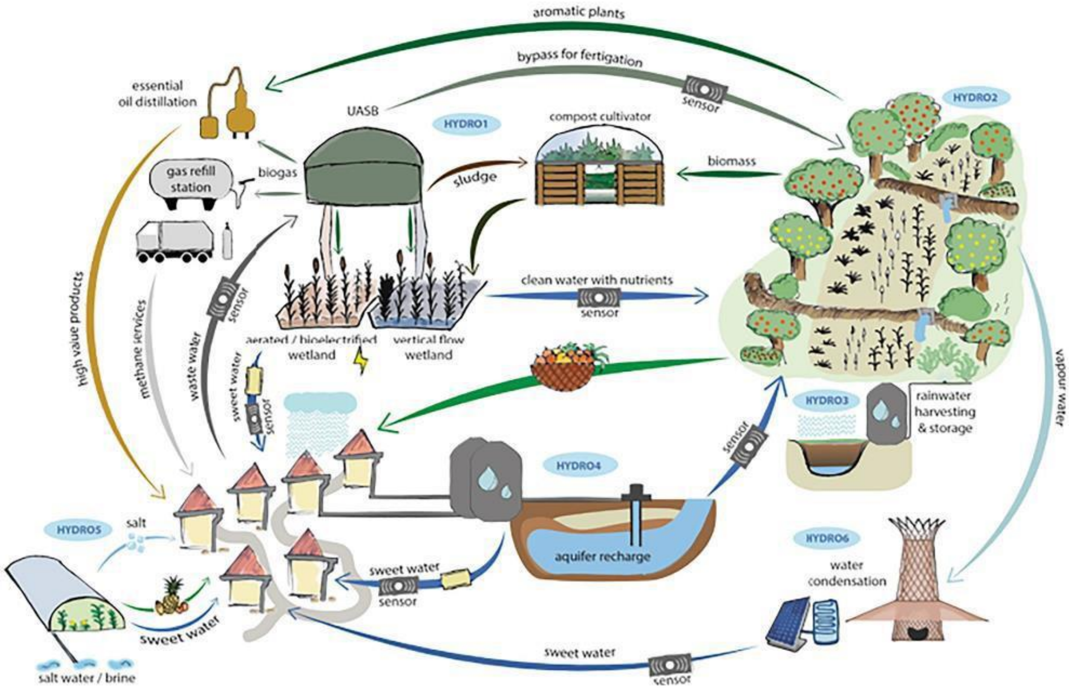

Figure (3) shows a layout of water supply chain in Mediterranean regions

Irrigation of green spaces:

The following succinct statement sums up the goal of using treated wastewater for agricultural irrigation:

A. Protecting land natural water supplies.

B. Prevent pollutants from harming the environment.

C. Ensure the population's health.

In Egypt, there are two types of agricultural wastewater reuse: direct and indirect. When wastewater is processed and reused directly, it can be used for irrigation and land reclamation. Collecting the combined effluent from treatment facilities and water from agricultural drains is known as indirect reuse. The direct use of treated wastewater for irrigation is covered in this study, along with any possible concerns to:

1. The Egyptian crops which irrigated with treated wastewater.

2. The health of agricultural products, consumers, farmers, and the environment.

3. The chemical and physical properties of the Egyptian soil and its sustainability.

Conventional approaches for wastewater treatment and disposal use minimally invasive treatment to lower organic pollution levels that are acceptable locally. In general, using wastewater for irrigation is not regarded as a disposal choice (Except for a few areas where water is scarce and therefore the acceptance of any water source supplementary to irrigation water). Consequently, the goal

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Instead of removing pathogens, the main goal of conventional wastewater treatment technologies is to minimize biodegradable organic matter (biodegradation).
The first step in these processes is primary sedimentation, which is then followed by activated sludge treatment, biofiltration, trenching oxidation, or aerobic lakes. Tertiary treatment and disinfection are occasionally used after these steps. Every step of processing needs time.
It only takes a little delay (one to four hours) to get rid of dissolved and suspended organic waste. However, it is insufficient to stop it. The production of the various systems necessitates limitations on the irrigated crops (example: crops that are mowed without irrigation are not irrigated).
Cooking, except for a) when disinfectants are used. b) Preserving treated water long enough to assure the destruction or suppression of disease-causing organisms. b) Employ irrigation techniques (such as drip irrigation or underground irrigation) that minimize contact with agricultural workers.

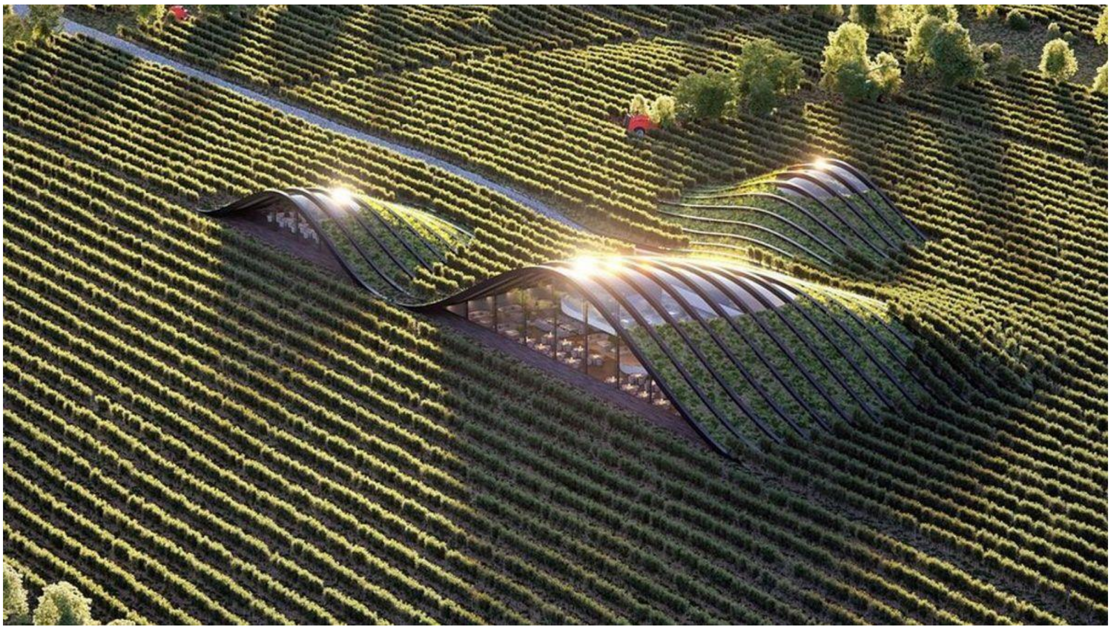

Figure (4) shows agriculture integrated with buildings in eco_cities

As shown in Figure (5), Water is extracted from wells by solar energy, then desalinated and pumped into residential community's supply networks, provided that the gray water resulting from human uses in buildings is separated and reused in agriculture, which contributes to returning that water to underground reservoirs to maintain the level of groundwater for wells For longer periods of time, which supports the effectiveness of the experiment to establish eco-cities in remote areas with low-salinity groundwater[14] [27].

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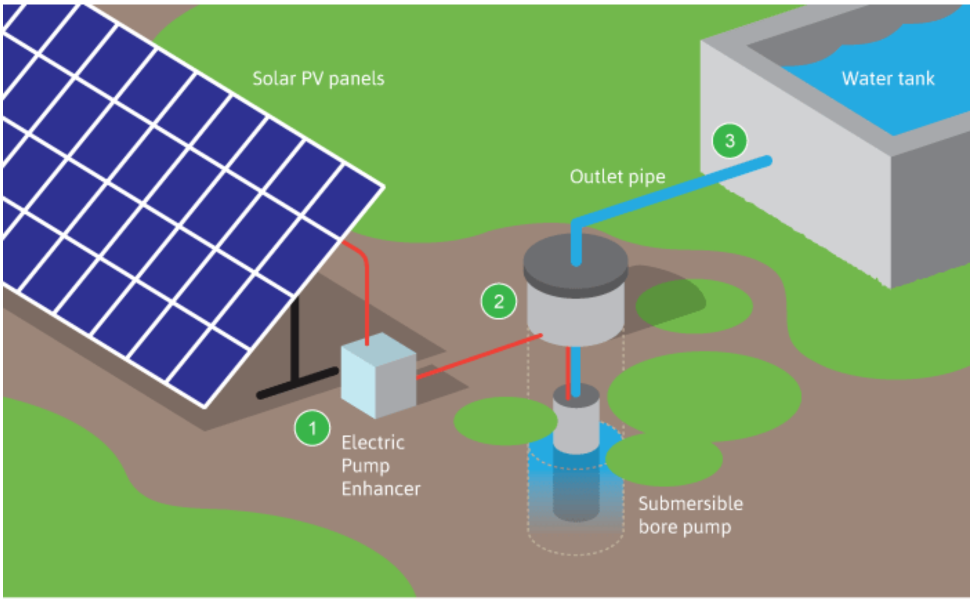

Figure (5) illustrates ground water extracted by solar energy.

The water is used to feed the residential communities, provided that the gray water resulting from the use of basins and showers in the homes is treated, which can be treated at the rates allowed for use in irrigation purposes to be used for irrigation, which contributes to feeding the groundwater reservoir in a way that ensures the sustainability of resources in the region. Figure (6).

Figure (6) shows greywater recycling

Pond construction for bettering the built environment:

In order to enhance the climate of dry places, treated water can be utilized to create ponds and water. Large artificial bodies of water called waste stabilization ponds. The pools can be used separately or in a sequence to enhance the cleansing process. Three different kinds of ponds exist: There are three types of ponds:

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(1) Anaerobic ponds
(2) Facultative ponds
(3) Maturation ponds, each with a unique design and processing characteristics.

For more effective treatment, the effluent stabilization (oxidation) ponds should be connected in a series of three or more ponds, with water flowing from the anaerobic pond to the facultative treatment pond, and finally to the aerobic pond. An anaerobic pond is the primary treatment stage that reduces the organic load in the wastewater. The entire depth of this somewhat deep pond is anaerobic. Removal of solids and BOD occurs by sedimentation and through anaerobic digestion within the sludge; Anaerobic bacteria convert organic carbon into methane, and through this process up to 60% of the BOD is removed.

The effluents from the anaerobic pond are transferred to the facultative treatment pond (aerobic - anaerobic), where further BOD is removed, in the series of progressive oxidation stabilization ponds. The natural diffusion of air, the mixing of wind and water, and the photosynthesis of algae are the sources of oxygen for the pond's upper layer. Without oxygen, the lowest layer becomes anaerobic or anoxic. Solids that have settled to the bottom build up and are digested there. Together, aerobic and anaerobic species can reduce BOD rates by as much as 75%.

Pathogens are removed by aerobic ponds, whereas BOD is removed by facultative treatment ponds and anaerobic ponds. Because it typically represents the culmination of a chain of curing ponds and reaches the highest level of curing, the aerobic pond is also known as a ripening pond or final pond. To make sure that sunlight reaches all the way down in order for photosynthesis to take place, it is not very deep. In addition to releasing oxygen into the water, the photosynthesis of algae also consumes carbon dioxide created by bacterial respiration. Dissolved oxygen concentrations are higher during the day and lower at night because photosynthesis depends on sunshine. The natural blending of wind and water raises the amount of dissolved oxygen as well.

Finally Reusing water presents a difficulty in terms of sustainability over the long run. There are two main issues with using recycled wastewater for irrigation: 1) potential issues brought on by high levels of sodium and salinity, and 2) high levels of nutrients or nutritional imbalance.

The depth of the water table, management practices, the salinity of irrigation water, and the kind of soil all affect how salty the soil is. Clay soil is more prone to sodium degradation and salt buildup.

A shallow water table can reduce leaching and introduce salts to the root zone. Therefore, the most salinity susceptible sites are sites with shallow water table, high clay content, poor drainage, and great soil compaction. Management practices that reduce water table, cap the topsoil with sand (especially for sports fields), improve drainage, and reduce compaction would reduce the potential sodium problems.

based on a survey of the literature and our prior studies. The best strategies for managing turf irrigated with reclaimed wastewater that we can suggest are as follows:

- Using water quality enforcement guidelines, regularly check the quality of the soil and water.

- Enough drainage and enough leaching to eliminate excess sodium and salts from the root zone;
- Additional chemical modifications to replace Na and lower the amount of exchangeable sodium;
- gypsum is added to irrigation water to change the SAR;
- Careful irrigation based on requirements for evapotranspiration and leaching;
- As a last resort, dual plumbing might be used to irrigate golf course greens with regular water in circumstances of abnormally high SAR or high salinity.
- To maintain oxygen diffusion and water flow, 9 more aggressive cultivation programs (deep aeration and water injection);
- More active traffic control initiatives.
- Fertilization with reduced nitrogen and phosphorus, taking into consideration the fertilizer value of recycled wastewater.
- Fertilize to correct an imbalance in nutrients.
- Substitute salt-tolerant species and cultivars for prone plants that are better matched to the soil and climate;
- Keep your plants healthy; they can handle salinity better.

4. Results And Discussion

Performance of each material in soluble reactive phosphate (SRP) Reduction

The chosen media were discovered to act differently both overall and across the various treatments (Table 2). Cal-OM had the greatest overall SRP reduction, while Cal-SW had the least. The performance of different media types was shown to differ statistically significantly, which made it possible to divide the media into three categories (Table 3). Cal-SH UR, Cal-OM, CCS, GAC, Egg, and Woll made composed the first group. For this group, the average PO4-P decrease ranged from 58.5 to 87.5%. The second group was made up of FCS, HAP, Cal-SH UR, GAC, Egg, and Woll. For this group, the average PO4-P decrease ranged from 53.3 to 75.6%. The average PO4-P reduction for the third group, which was made up of Cal-SH, FOX, Dolo, and Cal-SW, ranged from -0.6 to 13.8%. CCS, GAC, EGG, Woll, and Cal-SH UR, however, did not constitute a distinct group (Table 3).

Each medium's capacity to absorb SRP varied greatly. The wastewater solution used was only as concentrated as 100 mg PO4-P/L, which may have reduced each media's ability to adsorb. As a result, the maximum adsorption value presented indicates the highest adsorption found during these experimental conditions rather than a theoretical maximum value.

Behavior of Cal-SH UR and Cal-OM: It was discovered that the maximum adsorption of Cal-SH UR and Cal-OM (1.30 and 2.30 mg SRP/ g) was much greater than the values for calcite (1.09 and 0.68 mg SRP/g) published in the literature, while Cal-SH and Cal-SW (0.47 and 0.02) were low.

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Table 2 illustrates the removal efficiency of each media at different SRP Concentrations

	Initial SRP Concentration (mg / L)					
Media	**10**	**25**	**50**	**75**	**100**	**Mean Removal %**
Cal-SH UR	41.38	71.06	80.93	47.55	51.66	58.5
Cal-SH	5.66	25.90	-5.53	25.85	17.22	13.8
Cal-SW	-0.43	1.47	-0.16	1.09	-5.00	-0.6
Cal-OM	67.32	88.70	93.56	93.63	94.28	87.5
Woll	73.67	65.48	56.7	68.43	61.24	65.1
Dolo	-0.25	2.32	1.24	0.87	-1.56	0.5
HAP	62.30	57.44	37.81	60.29	48.57	53.3
Egg	12.76	66.60	84.68	83.99	82.81	66.2
FOX	-6.37	3.85	-4.44	14.31	20.50	5.6
GAC	62.82	68.22	65.19	82.43	91.52	74.0
FCS	42.36	30.40	62.83	69.70	64.84	54.0
CCS	51.52	56.75	87.68	91.04	90.80	75.6

Behavior of Dolo: Dole's maximum adsorption was significantly less (0.02 mg SRP/ g) than what was published in the literature (0.17 and 9.7-52.9 mg SRP/ g), proving that this sample is considerably less reactive than what has been previously studied 28 [17].

Table 3 shows the classifications of the used materials based on percent PO4-P reduction

Media	**Grouping**	**Average Reduction (%)**
Cal-OM	A	87.5
CCS	A B	75.6
GAC	A B	74.0
Egg	A B	66.2
Woll	A B	65.1
Cal-SH UR	A B	58.5
FCS	B	54.0
HAP	B	53.3
Cal-SH	C	13.8
FOX	C	5.6
Dolo	C	0.5
Cal-SW	C	-0.6

Behavior of HAP: HAP had good SRP adsorption (1.19 mg SRP/g), although the results were inconsistent with those reported in the literature. This HAP type outperformed four others (0.28, 0.31, 0.37, and 0.41 mg SRP/ g), although it was underwhelming when compared to the results (4.76 mg SRP/ g). This might be because wastewater solutions with

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initial SRP concentrations as high as 500 mg PO4-P/L were used in the latter investigation [18].

Behavior of eggshell: The maximum eggshell adsorption was found to be 2.08 mg SRP/g, which was significantly less than the values reported for calculated eggshells (23.02 mg SRP/g) but comparable to values reported for Fe-enriched eggshells in the literature (2.01 mg SRP/g). In a later investigation, other researchers determined that heating eggshells at 800 °C for two hours was the best method for calcining them; maximizing SRP adsorption due to the media's increased pore volume and surface area [19]. Because of this, it's probable that the lower temperature and lack of precise control throughout the calcination process in this investigation produced heterogeneous samples with varied media properties, such as surface area, pore size, and the amount of accessible Ca [20].

Behavior of CCS: For trials using comparable starting SRP concentrations, the maximum SRP adsorption of CCS (2.43 mg SRP/ g) and FCS (1.74 mg SRP/ g) were high compared to values published in the literature. Very little SRP adsorption from shell sands was seen by [21] and [22] at initial SRP concentrations of 10-100 mg/L; however, a significant increase in adsorption was observed at the initial SRP29. The level of focus increased. When using initial SRP concentrations up to 1,000 mg/ L, authors reported maximum adsorption capabilities that ranged from 8 to 17 mg SRP/g.

Behavior of FOX: In comparison to values reported in the literature, the maximum adsorption of FOX (0.55 mg SRP/ g) was generally low. Studies found maximum adsorption of 0.914 mg SRP/ g for anaerobically digested fiber biochar [23], 1.13 mg SRP/ g for mixed hardwood biochar [23], and 0.66 mg SRP/ g for softwood biochar. This validates earlier findings that the feedstock and the pyrolysis conditions under which the biochar was produced both have an impact on the specific surface area of the biochar.

Behavior of GAC: Under these initial SRP concentrations, the maximum adsorption of GAC was determined to be 1.68 mg SRP/ g, while substantially higher values have been reported (10.0 mg SRP/ g) when using starting SRP concentrations up to 1,000 mg/ L [24] . This demonstrates that GAC has the capacity to treat wastewaters with high SRP concentrations, such as effluent from dairy farms, and reach a greater maximum adsorption [25]. It is unclear why, despite the fact that the media behaved quite differently, the post-hoc statistical analysis for average SRP adsorption failed to find a statistically significant difference between the media performance.

5. Conclusion

The ability to reduce SRP was shown to vary greatly between the various media under study as well as between starting SRP concentrations. All treatments 31 revealed that the medium Cal-SH, Cal-SW, Dolo, and FOX performed poorly in terms of average percent SRP reduction and mass of SRP adsorption. The best performing media, according to statistical analysis, were Cal-OM, CCS, GAC, Egg, Woll, and Cal-SH UR, which saw average SRP reductions of close to 60–90% across all treatments. However, when comparing the average SRP adsorption across all treatments, no statistical differences were found between any of the media. However, the water resulting from the treatment processes was suitable for the proposed uses in the eco-cities, which saves 30% of the quantities of water needed for the cities, which supports the principles of eco-cities, foremost of which is recycling to provide self-resources. Therefore, the experiment is effective in rationalizing water consumption and reusing treated water in alternatives that drain fresh water that can be directed towards drinking uses and irrigating food plants.

6. References

[1] Shiba, Ahmed Salah Eldin " Effects of Climate Changes on Future Architecture and the Contribution of the Developing Countries to Limit and Avoid Harms". *Journal of Architecture, Arts and Humanities Science, ISSN: 2357-0342 Vol (6) Issue (26) , (2021). P. 1–13.* doi.org/10.21608/mjaf.2020.26108.1545

[2] S. Xue, T. Marhaba, and W. Zhang, “Nanobubble Watering Affects Nutrient Release and Soil Characteristics,” *ACS Agricultural Science and Technology*, Jun. 2021, doi: 10.1021/ACSAGSCITECH.1C00238.

[3] Mohamed N. Ali & Shiba, Ahmed Salah Eldin. "Grey water treatment reused and benefit of the heat capacity of water to improve the environmental performance of internal space". *Journal of Xi'an University of Architecture & Technology. ISSN: 1006-7930. Vol. XII (VII), (2020). pp. 983-992.* doi.org/10.37896/JXAT12.07/2408.

[4] V. H. Smith, S. B. Joye, and R. W. Howarth, “Eutrophication of freshwater and marine ecosystems,” *Limnology and Oceanography*, vol. 51, no. 1 II, pp. 351–355, 2006, doi: 10.4319/LO.2006.51.1_PART_2.0351.

[5] WHO, *Guidelines on recreational water quality. Volume 1, Coastal and fresh waters. World Health Organization, 2021.*, vol. 1. 2021.

[6] N. A. Serediak, E. E. Prepas, and G. J. Putz, “Eutrophication of Freshwater Systems,” *Treatise on Geochemistry: Second Edition*, vol. 11, pp. 305–323, 2013, doi: 10.1016/B978-0-08-095975-7.00908-6.

[7] J. P. Marshall and H. Wilcox, “How Green and Does it Clean,” *Developments in Surface Contamination and Cleaning*, pp. 1–69, 2015, doi: 10.1016/B978-0-323-29961-9.00001-6.

[8] C. Biasi, M. A. S. Graça, S. Santos, and V. Ferreira, “Nutrient enrichment in water more than in leaves affects aquatic microbial litter processing,” *Oecologia*, vol. 184, no. 2, pp. 555–568, Jun. 2017, doi: 10.1007/S00442-017-3869-5.

[9] H. W. Paerl, R. S. Fulton, P. H. Moisander, and J. Dyble, “Harmful freshwater algal blooms, with an emphasis on cyanobacteria.,” *TheScientificWorldJournal*, vol. 1, pp. 76–113, 2001, doi: 10.1100/TSW.2001.16.

[10] G. F. Lee and A. Jones-Lee, “Eutrophication (Excessive Fertilization),” *Water Encyclopedia*, Jul. 2005, doi: 10.1002/047147844X.SW1606.

[11] A. Tekile, I. Kim, and J. Kim, “Mini-review on river eutrophication and bottom improvement techniques, with special emphasis on the Nakdong River,” *Journal of Environmental Sciences (China)*, vol. 30, pp. 113–121, Apr. 2015, doi: 10.1016/J.JES.2014.10.014.

[12] V. H. Smith, “Eutrophication of freshwater and coastal marine ecosystems: A global problem,” *Environmental Science and Pollution Research*, vol. 10, no. 2, pp. 126–139, 2003, doi: 10.1065/ESPR2002.12.142.

[13] A. R. Jupp, S. Beijer, G. C. Narain, W. Schipper, and J. C. Slootweg, “Phosphorus recovery

and recycling-closing the loop," *Chemical Society Reviews*, vol. 50, no. 1, pp. 87–101, Jan. 2021, doi: 10.1039/D0CS01150A.

[14] Shiba, Ahmed Salah Eldin & Others "Supporting Eco-Cities by Utilizing Green Technologies in Wetlands for On-Site Wastewater Treatment" *Design Engineering ISSN: 0011-9342 | Year 2021 Issue: 3 | P. 940 - 954* http://www.thedesignengineering.com/index.php/DE/article/view/9658

[15] D. Krishna Veni, P. Kannan, T. N. Jebakumar Immanuel Edison, and A. Senthilkumar, "Biochar from green waste for phosphate removal with subsequent disposal," *Waste Management*, vol. 68, pp. 752–759, Oct. 2017, doi: 10.1016/J.WASMAN.2017.06.032.

[16] S. S. Dalahmeh, Y. Stenström, M. Jebrane, L. D. Hylander, G. Daniel, and I. Heinmaa, "Efficiency of Iron- and Calcium-Impregnated Biochar in Adsorbing Phosphate From Wastewater in Onsite Wastewater Treatment Systems," *Frontiers in Environmental Science*, vol. 8, Nov. 2020, doi: 10.3389/FENVS.2020.538539.

[17] S. Moosavi, C. W. Lai, S. Gan, G. Zamiri, O. Akbarzadeh Pivehzhani, and M. R. Johan, "Application of Efficient Magnetic Particles and Activated Carbon for Dye Removal from Wastewater.," *ACS Omega*, vol. 5, no. 33, pp. 20684–20697, Aug. 2020, doi: 10.1021/ACSOMEGA.0C01905.

[18] "ESICM LIVES 2021: Part 1," *Intensive Care Medicine Experimental*, vol. 9, no. S1, Oct. 2021, doi: 10.1186/S40635-021-00413-8.

[19] K. Annane, W. Lemlikchi, and S. Tingry, "Efficiency of eggshell as a low-cost adsorbent for removal of cadmium: kinetic and isotherm studies," doi: 10.1007/s13399-021-01619-2ï.

[20] O. G. Abatan, P. A. Alaba, B. A. Oni, K. Akpojevwe, V. Efeovbokhan, and F. Abnisa, "Performance of eggshells powder as an adsorbent for adsorption of hexavalent chromium and cadmium from wastewater," *SN Applied Sciences*, vol. 2, no. 12, pp. 1–13, Dec. 2020, doi: 10.1007/S42452-020-03866-W/TABLES/7.

[21] K. Ádám, T. Krogstad, L. Vråle, A. K. Søvik, and P. D. Jenssen, "Phosphorus retention in the filter materials shellsand and Filtralite P®-Batch and column experiment with synthetic P solution and secondary wastewater," *Ecological Engineering*, vol. 29, no. 2, pp. 200–208, Feb. 2007, doi: 10.1016/J.ECOLENG.2006.09.021.

[22] A. K. Søvik and B. Kløve, "Phosphorus retention processes in shell sand filter systems treating municipal wastewater," *Ecological Engineering*, vol. 25, no. 2, pp. 168–182, Aug. 2005, doi: 10.1016/J.ECOLENG.2005.04.007.

[23] J. D. Streubel, H. P. Collins, J. M. Tarara, and R. L. Cochran, "Biochar produced from anaerobically digested fiber reduces phosphorus in dairy lagoons," *Journal of environmental quality*, vol. 41, no. 4, pp. 1166–1174, Jul. 2012, doi: 10.2134/JEQ2011.0131.

[24] D. T. Curran, "Phosphate Removal and Recovery from Wastewater by Natural Phosphate Removal and Recovery from Wastewater by Natural Materials for Ecologically Engineered Wastewater Treatment Materials for Ecologically Engineered Wastewater Treatment Systems Systems."

[25] T. J. Goreau, "Electrical Stimulation Greatly Increases Settlement, Growth, Survival, and Stress Resistance of Marine Organisms," *Natural Resources*, vol. 05, no. 10, pp. 527–537,

ISSN: 0011-9342 | Year 2021
Issue: 4 | Pages: 2349 - 2367

2014, doi: 10.4236/NR.2014.510048.

[26] Shiba, Ahmed Salah Eldin "A Study of Spontaneous Architecture Environmental Characteristics and Treatments in Hot Dry Regions and their re-application in Contemporary Architecture Using Green Technology" International Journal of Advanced Science and Technology. ISSN:2005-4238.Vol.29(5s).(2020).pp.1819-1830. http://sersc.org/journals/index.php/IJAST/article/view/8577.

[27] Shiba, Ahmed Salah Eldin. "Generating Energy from the Movement Resulted from the Human activities for Confronting the Global Energy Crisis". Advances in Environmental Biology. ISSN:1995-0756. Vol. 08(2). February 2014, PP: 1931-1940. http://www.aensiweb.com/old/aeb/2014/1931-1940.pdf.

[28] Shiba, Ahmed Salah Eldin "Using Nanotechnology in Producing Organic Construction Materials". International Journal of Advanced Science and Technology ISSN: 2005-4238 Vol.(29) Issue (3), (2020). pp. 8174 - 8185. http://sersc.org/journals/index.php/IJAST/article/view/8570.