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9. A Comprehensive Approach to Application of Green Innovation and Technology

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Abstract:

Today, the increase in the world's population, especially in developing countries, has caused an increase in pollution, including water and soil pollution. The use of physical and chemical purification systems causes harmful effects on the environment, so it is suggested to use the capacity of plants to clean the pollution.

On the other hand, the phytoremediation process is faced with a time limit, and the use of nanoparticles is used as an aid in this process. Metal nanoparticles can pass through biological membranes and cause adverse effects on the environment.

Our proposal is the synthesis of green nanoparticles based on plant extracts, which is sustainable with the environment. We suggest that vetiver root extract is used as a hyperaccumulating plant in the synthesis of nanoparticles and its application in the phytoremediation process is investigated.

Keywords:

Plant remediation, heavy metals, nanoparticles, sustainable environment

9.1 Introduction:

Figure 9.1: Green Technology

Life is impossible without one of the most important natural resources, water. About 74% of our earth consists of water.

At present, the quality of water has decreased due to various pollutions, and it has made water difficult for consumption and other uses, in other words, clean water is one of the biggest concerns of the 21st century. Clean water has become an increasingly scarce and precious resource.

Rapid industrialization has caused the production and release of a significant number of pollutants in water sources and has caused the increasing pollution of water sources.

Although the earth's texture holds about 74% of the surface water, but unfortunately only one percent of the surface water is suitable for drinking. The discharge of sewage directly or indirectly into groundwater has increased significantly due to the increase in human population, the development of agricultural and industrial activities [1].

9.1.1 Environmental Problems:

Water pollution is due to the entry of many undesirable chemical compounds into water systems. With the increase in global population, especially in the third world and developing countries, the housing density has increased significantly and the sewage systems for most of these housings are very poor. Sewage causes significant damage to the environment, fisheries, tourism and drinking water sources. Preventing the pollution of surface water sources, as the main source of drinking water used by humans, has a major contribution to the development of national and regional health. The increasing use of heavy metals in industries and agriculture has caused serious concern for environmental pollution, and the high concentration of these heavy metals causes serious damage to plants. The increasing pollution of heavy metals in the environment through the erosion of agricultural land, urban waste, rural activities, industrial activities and mining industries has increased the concerns of the world, especially in developing countries [2].

At present, the pollution of all types of sewage is increasing and as a result of the accumulation of heavy metals in plants and animals, in addition to causing serious damage to these organisms, the consumption of their products has become very dangerous for the health of the final consumers, i.e. humans. Is. Also, a comprehensive understanding of the sources of this type of pollution and the process of their changes and removal in wastewater treatment plants is necessary to minimize their effect on the water and soil environment and to reuse them.

However, the assessment and identification of sources of heavy metals in urban wastewater is a complex task and requires continuous monitoring due to the temporal changes in wastewater quality, population dispersion, and the location of sources of pollutants. So that the lack of adequate monitoring of the quality of effluents and sludges from the country's treatment plants has caused that in most cases these substances are accumulated in the environment and cause great damage to natural resources and water, soil and agricultural products and cause the spread of chronic diseases [3]. Soil contamination with heavy metals is one of the basic problems of ecosystems. If the contaminated soil is not cleaned and purified and the existing pollutants are not removed or decomposed, the pollutants will gradually penetrate deep into the soil. Heavy metal pollution has become one of the most serious environmental problems today, and the treatment of soils contaminated with heavy metals is one of the most important issues in environmental health.

Heavy metals generally enter water supply systems as fine solid particles, metal dust, and other contaminants and can eventually turn into sediments. Plants require a significant number of metals in very small amounts for growth and development, however, some biogenic elements such as zinc (Zn), selenium (Se) and copper (Cu) are toxic in high concentrations and may be Some types of sewage can be found. Other metals such as arsenic (As), lead (Pd), mercury (Hg), cadmium (Cd), thallium (Tl) and uranium (U) have also been detected in municipal and industrial wastewater and other wastewaters, but no value.

They are not biological for living organisms and are toxic in relatively small quantities. Toxic minerals such as ammonium, sulfide, salts, and metals in wastewater may inhibit nutrient uptake and plant growth at concentrations greater than wetland plants can tolerate. Due to urbanization and industrial development, pollution of unnecessary heavy metals such as lead (Pb), chromium (Cr) and cadmium (Cd) in water and soil has recently attracted much attention. It has been reported that unnecessary heavy metals are usually strong poisons and their accumulation in tissues leads to poisoning, reduced fertility, cell and tissue damage, cell death and organ dysfunction [4].

9.1.2 Municipal Sewage:

Atmospheric precipitations move down under the effect of gravity and in contact with garbage, through chemical and physical reactions, they dissolve particles and waste materials. The reaction of the particles inside the garbage with water and moisture between the garbage itself creates a viscous liquid called garbage leachate, which has a very unpleasant smell. The production of leachate is one of the operational consequences of burying waste in a landfill. Of course, apparently, burying urban waste is one of the cost-effective ways to dispose of waste from the human environment. In this method, the waste is spread and compacted among the soil and then covered with another layer of soil. Burial and accumulation of waste causes the release of leachate in the soil and the surrounding environment, which, if not properly directed and collected, has irreparable effects on the environment and the surrounding soils [5].

The sap contains various types of organic and inorganic compounds that can be dissolved or suspended. These compounds pose serious risks to the surface and underground water resources of the region. Chemicals from waste leachate are either absorbed by soil particles in the form of adsorbents or trapped between soil particles as an insoluble liquid. With the passage of time, the chemicals obtained from the waste leachate, which have been absorbed by the soil particles, spread in the soil texture and cause soil pollution on a larger scale, which have a significant impact on the environmental behavior and soil engineering [6].

9.1.3 Industrial Wastewater:

Industrial wastewater is very important due to the complexity of its qualitative and quantitative characteristics. Wastewaters from industrial productions and factories, in addition to destroying natural resources, impose additional pressure on the planet's ecosystem. The quantity and quality of industrial wastewater is proportional to the production process. The ease of access and the cost of water supply and sewage disposal, the type of raw material and production products, the level of supervision of the operation of the industrial unit, the area of green space and grounds, the state of health-welfare facilities, the existence of recycling systems and the amount of reuse change [7,8].

9.1.4 Green Innovation and Technology:

The term phytoremediation is defined as the use of plants to remove or eliminate hazardous pollutants from water, soil and air. Phytoremediation is derived from the Greek word Phyto, which refers to a plant, and the Latin suffix Remedium, which means treatment or restoration. The main reason for using this method is to collect pollutants and convert them into a suitable and extractable form, i.e. plant tissues. Compared to other techniques, phytoremediation has many advantages, and this method can also minimize the disturbance in the environment [9].

The term phytoremediation describes a broader understanding of the importance of plants and their beneficial role in social and natural systems. Phytoremediation has been introduced and developed for the treatment of urban water runoff, domestic and industrial wastewater, and remediation of contaminated soil for the past three decades. Phytoremediation is not only recognized as an effective tool for improving water quality and watershed control, but also provides beauty and wildlife habitat [9,10]. Vegetation treatment systems are generally simple, economical and do not have harmful effects on the environment and natural resources. The most important factor in the implementation of biological treatment systems is the selection of suitable plant species, which must have unique characteristics such as high absorption of organic and inorganic pollutants, adaptability and proper growth in polluted environments, and easy and fast reproduction. The results of various researches have shown that even in the same species, the absorption rate of pollutants is different from one species to another [11].

Among the other characteristics of a plant for phytoremediation is that the plant must tolerate the accumulation of high concentrations of metals in its branches. Plant remediation is known as Bioremediation, Botanical bioremediation, green remediation. The idea of using hyperaccumulating plants, which have the ability to purify pollution, was first proposed in 1983. Although there is a good image of phytoremediation, not many field studies have been conducted on this method and there is not enough information to support its commercialization. This is one of the reasons for the slow spread of phytoremediation [12].

For this reason, chemicals are used to accelerate the process of phytoremediation, and these compounds are used to improve the efficiency of refining metal elements by plants in order to increase the solubility of metal elements. As a result, in recent years, many studies have been conducted in the field of increasing plant remediation performance, one of which is studying the behavior of nanoparticles, considering the rapid development and widespread use of nanoparticles and the simultaneous risk of ecosystem pollution, understanding the interactions between ENPs and aquatic plants and evaluating Possible effects on metal uptake and phytoremediation processes are very important.

The absorption and accumulation of ENPs in plants plays an important role in phytoremediation of ENPs. The accumulation of ENPs by aquatic plants is a complex process, in which plant physiology, ENP transformations, and environmental components interact to drive this process. Aquatic plants are very different in terms of physiology and morphological differences in leaf, root and vascular systems. Hence, the mechanisms of nutrient absorption will also be different. Plant uptake is influenced by a variety of factors including particle size, charge, shape, and surface functionality. All these changes depending on the conditions of exposure; plant species and varieties; plant growth stage; root integrity (damage or disease); Growing conditions can vary.

Nanotechnology refers to applied research and development of science at the atomic or molecular level. One of the defining characteristics of nano materials is that they behave differently from the behavior of macro-structured or macro-structured materials. It should be noted that with the increase in the surface ratio, the free energy of the material also increases, which itself causes changes in the properties of the material.

When ENPs enter water and soil, they undergo several physical, chemical and biological changes. ENPs may undergo dissolution, aggregation, adsorption, deposition, oxidation reactions, and other processes that often occur simultaneously, all of which affect the changes that may occur in the nanoparticle. Aquatic environments include ponds and lakes, rivers, wetlands, and saline and marine ecosystems. As a result, the chemical composition varies widely. The variables we mentioned can contribute to a wide range of possible changes in the behavior and fate of ENP in these ecosystems [13]. There are different types of nanoparticles, most of the studies have been done on metal nanoparticles and their functions, but the main question related to metal nanoparticles is how they enter and accumulate in plants and in the environment. How can these effects be controlled?

9.2 Material and Method:

We searched many articles with the keywords of phytoremediation, environment and heavy metals and studied all the articles and selected 23 of the 60 articles based on the purpose of our work and the total of the studies in one work provided an overview.

9.3 Result and Resource Review:

In a study on Persicariahydropiper L (water pepper), which belongs to Polygonaceae family, it shows that lead stress significantly affects plant growth (stem and root length), biomass (fresh and dry) and total water content in parts It has stopped the plant and the whole plant. All tested concentrations of ZnO NPs improved plant growth and biomass accumulation, but at higher concentrations, i.e. 20 mg of nanoparticles, the researchers encountered a decrease in growth traits. It was observed that the concentration of nanoparticles from 5 mg to 15 mg was associated with an increase in growth, but from 20 mg, it was observed that the growth decreased. The concentration of lead in different parts of the plant and in the whole plant increased significantly with the use of ZnO NP compared to the control with only lead [14]. In the present study, the effects of untreated municipal wastewater on the physiological processes of corn and the evaluation of the role of Ag nanoparticles and PGPR (Plant Growth-Promoting Rhizobacteria) in interaction with municipal wastewater are measured, in other words, the effect of nanoparticles and bacteria on the plant remediation process is investigated. In this study, corn plant seeds were inoculated with three strains of bacteria and then cultivated and irrigated with wastewater and silver nanoparticles were sprayed in certain scales. The strains with which the seeds were inoculated are Planomicrobiumchinense, Bacillus cereus and Pseudomonas fluorescens.

The observed increase in chlorophyll and carotenoids of plants inoculated with PGPR and irrigated with wastewater can be attributed to the effect of wastewater and bacteria due to the availability of plant nutrients provided by the bacteria, as well as the organic matter content in Effluent Ag nanoparticles were stimulatory for root and shoot growth and enhanced the stimulatory effect of wastewater and PGPR on root and shoot growth. Ag nanoparticles showed a significant increase in the proline content of treated plants, which was much higher than the proline content of plants treated with wastewater or plants treated with PGPR [15]. In a study on the Populus deltoids plant, which belongs to the Salicaceae family, the effects of nC60 fullerene nanoparticles on the absorption of trichlorethylene by plants in phytoremediation systems were investigated.

Trichloroethylene (in English: Trichloroethylene) which is known as TCE is a chemical compound that is generally used as an industrial solvent. The use of TCE in the food and pharmaceutical industries has been banned in many countries due to its toxicity.

Plants were examined after 4 days of exposure to nanoparticles, the samples containing fullerene nanoparticles, the concentration of TCE or plant biomass has a positive relationship with the concentration of fullerene in the solution, and the concentration of nC60 increases the concentration or mass of TCE in plant tissues [16].

Well, as we have seen in previous studies, engineered nanoparticles have a positive effect in the plant remediation process, stimulating antioxidant enzymes and also stimulating the production of compounds such as proline, increasing the capacity of hyperaccumulating plants to absorb and maintain heavy metals and other pollutants. On the other hand, we observed that nanoparticles act in a dose-dependent manner, which raises a question for us, since nanoscience is used in other processes, does the introduction of various types of nanoparticles through industrial activities into Can the environment be an alarm for us?

Considering the fact that nanoparticles have the power of transmission in plants, can this be a positive feature to prevent environmental pollution? Examining a study reminds us of an important point, although nanoparticles can improve the performance of plant remediation, but if they are used in unconventional doses, they can even have harmful effects on the environment. The fact that plants have the ability to absorb them will be a promising point in future research.In this research, the aim of investigating the effects of zinc oxide nanoparticles (ZnO NPs) on the physiological parameters of Solanumnigrumcalli and the possibility of using it as a purifier for polluted environments was carried out. In this research, three doses of nanoparticle concentrations were used, which included 0, 50, and 100 mg in the culture medium, and then the calluses were analyzed. Different concentrations of zinc NnO cause variable effects on callus growth.

Treatment with 50mg L-1 showed a significant increase in DW and this increase was about 80% more than the control. On the other hand, the treatment of 100 mg L-1 ZnO NPs reduced the callus tissues by 30% compared to the control. In the following, you can see that the activity of antioxidant enzymes increased with the increase in the dose of nanoparticles [17].

A study has been done on Pistia stratiotes, which is called blue lettuce. In this research, the ability to refine silver and also silver nanoparticles by blue lettuce plant was investigated in several doses of nanoparticles. In this study, according to the results, we can understand the effect of dosage on the performance of nanoparticles. Specifically, in optimal doses, they have a positive effect on plant absorption and growth characteristics, while in higher doses, they have the opposite effect on plant performance.

If we consider the optimal dose under these conditions, can we say that metal nanoparticles do not have a destructive effect on the environment? Since nanoparticles have small sizes, they can easily pass through biological systems, especially biological membranes. What to do with this problem? In the following, you will read our proposal regarding the synthesis of these compounds.

9.4 Our Proposal for The Development of Green Technology:

In recent years, the development of green chemistry methods specifically for the synthesis of metal nanoparticles has attracted the attention of researchers. Much research has been done to find an environmentally friendly technique to produce nanoparticles with suitable properties. One of the most important methods of producing metal nanoparticles is the use of living organisms. Among these organisms, plants seem to be the best candidates for large-scale synthesis of nanoparticles.

Nanoparticles produced by plants are more stable and their synthesis rate is faster compared to microorganisms. The advantages of using plant materials for the biosynthesis of metal nanoparticles have made researchers interested in researching the mechanisms of absorption and transport of metal ions by plants and understanding the possible mechanism of the formation of metal nanoparticles in plants.

Nanoparticles due to their very small size and high surface-to-volume ratio, chemical and physical differences (including mechanical properties, biological properties, catalytic activity, electrical conductivity and optical absorption and melting point) compared to the same primary chemical composition in larger dimensions., Is different. Therefore, by controlling the scale of shape and size, it is possible to design and produce materials with new applications.

These particles also have many applications in various fields such as medical imaging, nanocomposites, filters, drug delivery and tumor hyperthermia. Gold and silver nanoparticles are the most common ones used for medical applications and in the new interdisciplinary fields of nanobiotechnology.

Gold nanoparticles have been used in immunoassays, protein assays and cancer nanotechnology (especially cancer cell detection). In the medical field, gold nanoparticles are used for various purposes, including as markers for screening tests. Silver nanoparticles have attracted the attention of researchers due to their wide applications in areas such as integrated circuits, sensors, filters, antimicrobial deodorant fibers, cell electrodes and antimicrobial materials.

Physical and chemical nanoparticles have been produced for a long time, but recent developments show the vital role of microorganisms and biological systems in the production of metal nanoparticles. The use of organisms in this field is rapidly developing due to the increasing success and ease of nanoparticle formation.

In addition, the biosynthesis of metal nanoparticles is an environmentally friendly method (green chemistry) without the use of expensive, toxic and chemical substances. Organisms used in the synthesis of nanoparticles vary from simple prokaryotic bacterial cells to complex eukaryotes. In fact, the ability of organisms to produce metal nanoparticles has created a new approach for the development of natural nanoparticles. mportant aspects that should be considered in the process of producing sustainable nanoparticles are: Selection of the best organisms in order to select the best candidates for the production of metal nanoparticles, researchers have focused on the intrinsic and important characteristics of organisms such as enzyme activities and biochemical pathways. are for example, plants that have a great potential in the accumulation and detoxification of heavy metals are the best candidates for the synthesis of nanoparticles, optimal conditions for cell growth and enzyme activity are very important to optimize growth conditions, nutrients, light, temperature, pH, speed Mixing and buffer strength should be optimized. Therefore, we need to optimize the bioaccumulation conditions in the reaction mixture [18].

Currently, the biosynthesis of metal nanoparticles by plants is being exploited. Biological synthesis of metal nanoparticles (especially gold and silver nanoparticles) using plants (passivated plant tissue, plant extracts and living plants) as a suitable alternative to chemical methods and physical methods has received more attention.

The synthesis of metal nanoparticles using plant extracts is very cost-effective and therefore can be used as an economical and valuable option for large-scale production of metal nanoparticles. The synthesis of metal nanoparticles using the combination of biomolecules found in plant extracts (for example, enzymes, proteins, amino acids, vitamins, polysaccharides and organic acids such as citrates) is very beneficial from an environmental point of view, but in terms of It is chemically complex.

Plants have shown great potential in the accumulation and detoxification of heavy metals. Various types of plants such as Acanthopanaxsciadophylloides, Maytenusfounieri, Brassica juncea, Ilex crenata, Sesbaniadrummondii and Clethrabarbinervis have a potential capacity to purify heavy metals. The use of plant biomass for metal removal from aqueous solutions (biosorption) was considered because it has been shown that the removal of pollutants from wastewater is an environmentally friendly and very promising approach.

The natural phenomenon of heavy metal tolerance in plants makes researchers interested in researching the relevant biological mechanisms as well as the physiology and genetics of heavy metal tolerance in hyperaccumulating plants. In order to use plants for the production of metal nanoparticles, researchers pay attention to the use of plants with the potential of phytoremediation of heavy metals.

Magnetite nanoparticles have attracted much attention for many important technological and biomedical applications such as drug delivery, cancer hyperthermia, optical and nanoelectronic devices, magnetic separation, and imaging enhancement.

In order to synthesize magnetite nanoparticles, various chemical and physical methods have been reported, but some of the chemical methods involved in the synthesis of these nanoparticles use toxic solvents that can produce toxic and dangerous side products. And they often have high energy consumption.

New methods for the synthesis of nanoparticles are the use of biological systems. It has been reported that iron oxide nanoparticles can be synthesized using alfalfa biomass.

With pH in the range of 10, smaller particles with a higher proportion of Fe_2O_3 were synthesized, the particle size could be controlled in the range of 1-4 nm, when the pH decreased (pH 5), larger nanoparticles were produced.

In a research, silver uptake by two common metallophytes, Brassica juncea and Medicago sativa was investigated. They showed that B. juncea and M. sativa can be used in bioproduction (phytoextraction) of metallic silver nanoparticles. B. juncea, exposed to an aqueous medium containing 1000 ppm silver nitrate for 72 hours, accumulated silver up to 4.12% by weight. M. sativa exposed to an aqueous medium containing 10,000 ppm silver nitrate for 24 h accumulated up to 13.6 wt% silver. In the case of M. sativa, an increase in metal absorption was observed with an increase in the concentration of the substrate and the duration of exposure to the substrate [19].

The use of plant systems is considered a green way and a safe method for the biosynthesis of nanoparticles due to its ecological nature. It is evident from previous reports that plants have been very successful for the extracellular biosynthesis of metal nanoparticles. Gold and silver nanoparticles can be synthesized using plant extracts.

In one study, gold nanoparticles were formed when lime leaf extract reacted with aqueous $AuCl4^{-}$ ions. In addition, it has been reported that the extracts of the leaves of different plants, plantain, oleander, geranium and aloe vera, have shown their potential ability to convert silver ions into silver nanoparticles. Similarly, the synthesis of platinum and palladium nanoparticles using extracts of different parts of plant species has been reported [20].

Among the biological processes, the biosynthesis of silver nanoparticles is an easy and fast method. The researchers reported that by placing geranium leaf extract in silver nitrate solution, they synthesized highly stable and crystalline silver nanoparticles (16-40 nm).

The rate of synthesis of nanoparticles in the reaction was very high (reaction time 60 min), indicating that plants rather than microorganisms are a much faster method for biosynthesis of nanoparticles. In the continuation of the same research group, an interesting experiment was conducted using plant leaf extracts, including Helianthus annus, Basella alba, Oryza sativa, Saccharumofficinarum, Sorghum bicolar and Zea may, and it was concluded that among all the tested extracts, Plant. H. annus showed the strongest potential for rapid ion reduction. Extracellular synthesis of silver nanoparticles using pine, persimmon, ginkgo and magnolia leaf extracts has been reported.Likewise, researchers reported the rapid synthesis (reaction time less than 30 minutes) of silver nanoparticles using Acalyphaindica leaf extract and their antibacterial activity against pathogens [21].

Gold nanoparticles are preferably the most attractive metal nanoparticles due to their potential applications in various fields including gene expression, nanoelectronics and disease diagnosis. Recently, several studies have independently reported the reduction of aqueous chloroarate using different plant parts. In one study, the leaf extracts of three different plants were tested in the synthesis of gold nanoparticles to reduce the aqueous solution of chloroarate, the investigated plants included Eucalyptus camaldolensis, Pelargonium roseum and A. indica. The results showed that all the tested leaf extracts have the ability to produce gold nanoparticles, but when menthol extracts of E. camaldulensis and P. roseum were used compared to A. indica leaf extracts, a significant increase in the performance of nanoparticles in reducing the solution Blue chloroarate was observed [22].

Platinum palladium nanoparticles have been well studied in recent years. During a study on the formation of palladium nanoparticles using Gardenia jasminoides plant extract, they stated that the antioxidants ginoposide, chlorogenic acid, crocins and crostin played a very important role in stabilizing the nanoparticles, while the dispersion of these nanoparticles was dependent on temperature. In addition, the synthesis of platinum nanoparticles was investigated using Diopyros kaki leaf extract, and it was found that more than 90% of platinum ions were converted into nanoparticles using a concentration of 10% of leaf biomass at 95 °C, and the average size of nanoparticles synthesized from It was 2 to 12 nm [23-28]. We also have reached to this point that herbal capacities for all ranges and with health treatment rules can support better overviews to the future [29-32].

9.5. Discussion:

We reviewed the results of the studies and found important points related to the dose of nanoparticles. Nanoparticles in specific doses can be useful for the plant remediation process, but since they are metal nanoparticles, can they create a separate risk for the environment? We know that nanoparticles have very small sizes and can pass through biological membranes. With more specialized studies, we have reached the basic point that by using plant metabolites, we can synthesize green nanoparticles that not only improve the plant remediation process, but are also environmentally friendly and change form from metal nanoparticles to green nanoparticles. give Our proposed plan is to use the extract of high-accumulative plants to produce green nanoparticles, which you can see in Figure 9.1.

In this plan, we suggest that instead of using medicinal plant extracts, vetiver root extract should be used as a hyperaccumulating plant for the synthesis of green nanoparticles, and finally, it should be used in conventional doses to improve the phytoremediation process\ and the results are recorded.

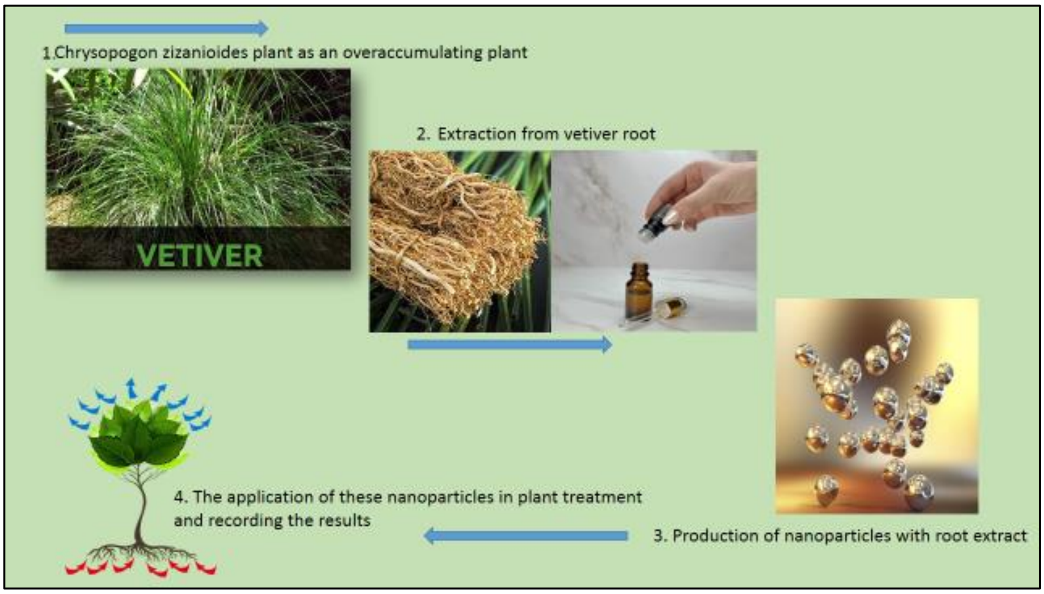

Figure 9.2: Our proposal

9.6 Conclusion:

According to the studies, the use of plant extracts that have effective compounds, for example, the menthol compound in the Naa plant, has a great effect on the efficiency of nanoparticles. In addition, according to the studies conducted, silver and gold metals are more useful than other metals in the synthesis of nanoparticles, since in addition to their effect in reducing toxicity, they show abilities in fighting pathogens. They can have a double function in this regard. In addition, it is possible to use the extracts of medicinal plants that have effective compounds for the synthesis of metal nanoparticles and use these nanoparticles synthesized with the extracts of medicinal plants to increase the performance of hyperaccumulating plants.

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