Chapter

Modern Trends in Uses of Different Wastes to Produce Nanoparticles and Their Environmental Applications

Salah Abdelbary and Hadeer Abdelfattah

Abstract

Wastes are produced at large amounts all over the world. These wastes cause a variety of problems to the ecosystem, plants, animals, and humans. In this chapter, we discuss the wastes, types of wastes, sources of wastes, and problems related to wastes, especially health-related problems. Then we discuss agricultural wastes and how we can synthesize different nanoparticles from them. Also, we discuss industrial wastes and different nanoparticles synthesized from them. Additionally, we discuss fruit wastes and production of different nanoparticles and also food wastes and their uses in nanoparticle syntheses. Also, we can use other wastes to produce nanoparticles. In applications section, we discuss the use of different nanoparticles produced in agriculture, removal of heavy metals and pollutants from environment, industry and finally medical applications. We will finish our chapter with the topic of healthy and safe synthesis of nanoparticles produced by different wastes and then conclusion.

Keywords: wastes, nano-cellulose, metal oxide nanoparticles, nano-carbon and environmental pollutants

1. Introduction

Wastes are unwanted, unused or useless, and disposed of after primary use. On the other hand, a product in the product can be a collective product with small measures. They are disposed of or are intended for demolition or are required to be demolished in accordance with the provisions of national law [1]. Waste materials can be turned into products or resources by innovations that increase the value of waste products above zero. Waste can also be created during raw material extraction or recycling into intermediate and final products [2]. Also, the waste is solid or gaseous, and it is chemically toxic or harmful, esthetically offensive, or radioactive. Some waste involves only temporary repression, while others can be isolated indefinitely [3]. The list of potential health problems that are important in the context of hazardous waste exposure was presented by the Agency for Toxic Substances and Diseases and includes birth faults and reproductive complaints, cancers, immune illnesses, renal and liver dysfunction, respiratory diseases, and neurotoxic disorders [4].

Green synthesis of nanoparticles has recently aroused great interest due to its advantages such as being economic, simplicity, environmental friendliness, biosynthesis, and widespread use in conventional chemical and physical methods [5]. Nanomaterial production originates from a variability of wastes including crop remains, industrial wastes, and food wastes. To this end, a variety of treatment methods have been developed and implemented to convert waste into useful nanotubes by chemical and thermal action, pumping, gas condensation dust, reduction of sodium borohydride, and thermal method of the solvent [6].

The application of nanotechnology in various fields such as health and medicine, electronics, energy, and the environment are wide. In the field of water purification, nanotechnology offers the opportunity to effectively remove dirt and bacteria. Adsorption has proven to be the best process for water purification technology due to its key advantages [7]. The use of nanotubes in drug delivery, protein delivery, and cancer peptide delivery has been explained. Different types of nanoparticles in cancer treatment are provided, such as carbon dioxide nanoparticles and wire nano-shells [8].

In this chapter, we discuss the sources and types of different wastes, their problems on the environment, their use as a source of synthesis of nanoparticles, and then the application of these produced nanoparticles in different applications especially in the environment.

2. Wastes

2.1 Sources and types of wastes

2.1.1 Agricultural wastes

Agricultural wastes can be defined as residues from the cultivation and processing of raw agricultural products such as fruits, vegetables, meat, poultry, dairy products, and crops. Agricultural waste can be solid, liquid, or lubricant depending on the nature of the agricultural activity. In addition, agricultural wastes play an important part of global agricultural productivity [9]. Agricultural waste, which includes both organic (organic) and nonorganic wastes, is a general term used to describe farm-generated waste through various agricultural activities. These activities may include, but are not limited to, milk, horticulture, seed production, animal husbandry, garden, nursery, and even forestry. Wastes from agriculture and the food industry make up a significant portion of global agricultural productivity. It is estimated that this waste may account for more than 30% of global agricultural productivity [10]. Agricultural waste today is very challenging, and many agricultural wastes are present in our environment every day. The latest trend in biofuel production from agricultural waste is in-depth research. Various processes such as chemical heat, gas emissions, liquid emissions, combustion, combustion, and rapid pyrolysis processes can be studied to obtain biofuels from agricultural wastes such as corn, straw, wheat, and rice straw [11].

2.1.2 Industrial wastes

Industrial wastes present at a huge amounts and cause a lot of pollution. There is a global consensus to reduce such waste to reduce biological burden [12]. Contribution involves industrial waste recovery, especially from mining and metallurgical enterprises. Waste is processed in the form of hydraulic loads that can be disposed of in closed underground mines [13]. Industrial waste must be compatible (treatable) with sewage. Industrial waste must be limited and proportional to the flow and burden of sewage pollution. Industrial waste shall not be toxic or harmful to the operating purpose of the treated plant material. Industrial waste should not contain harmful substances to service personnel or those from the environment near the septic tank [14]. Industrial waste is either directly connected to streams or other natural water bodies or dumped into sewers. In this way, this waste, in one way or another affects the normal life of the stream or the normal functioning of sewers and treated plants. Water can discharge a certain amount of waste before it gets dirty, and municipal wastewater treatment plants can be designed to treat all kinds of industrial waste [15]. Typically, industrial waste can be divided into two categories, hazardous and nonhazardous. Nonhazardous industrial wastes do not cause environmental and health hazards and are produced from cardboard, plastic, iron, glass, stone, and organic waste. In contrast, hazardous wastes are industrial waste that can be harmful to public health or the environment, such as flammable, biodegradable, and hazardous materials [16]. Industrial waste is classified as wastewater, solid waste, or air leaks. There is some overlap in the physical properties of the substances present in these three categories, as wastewater can contain suspended solids and suspended liquids and precipitation of solid waste can include gas, liquid, and some liquids. Particles and air exposures may consist of a fluid that emits air fluid and a substance known as particle emission [17]. Industrial waste, which has a significant concentration of nonrecyclable or recyclable metals, is usually a good candidate for landfill, which is the dumping of waste into the ground area [18].

2.2 Environmental problems of wastes

2.2.1 Agricultural waste problems

Air pollution as a result of agriculture Very low but emissions from agricultural machinery and farm wastes is a common in many developing countries. Agriculture is a major source of water pollution and land resources. In view of the large water pollution caused by agriculture, special emphasis is placed. Leaking agricultural commodities can also be fatal to human's health problems. For example, carrying the pathogen can increase significantly by leaked and stagnant water bodies. When these sources used to meet drinking water needs, water infections can occur, especially in rural areas [19]. Pesticides, fertilizers, and agricultural wastes can cause severe water and soil pollution in the region. In recent years, it has also been clear that agriculture has been a major source of air pollution, with consequences that are long-term and universal [20]. Recognize that some nitrate may exist in nature with low water concentration, and any form of agriculture is likely to raise the level of nitrate [21].

2.2.2 Industrial waste problems

Industrial pollution continues to be a major factor in worsening the environment around us, the water we use, the air we breathe, and the land we live in. The growing power of industrialization has not only consumed large agricultural land but at the same time has caused environmental degradation as well as land. Water from various industries finds its place in agriculture [22]. Waste released by industries such as sugarcane, sugarcane and resin, textile, viscose, latex, and oxalic acid have been evaluated and proven useful in agriculture. Other wastes such as sewage and sediment, fly ash, flowerpots, mud and biogas, and biowaste also have proved to be useful for increasing plant production and fertilizer savings [23]. In the course of waste production, solid and liquid industrial wastes were created. There are many elements that can be valuable components for agriculture and fertilizer and produced from industrial wastes. These wastes accumulate in significant quantities due to the high chemical content [24]. Human activities such as extraction and emission, burning of fossil fuels and fossils, as well as the use of organic and other chemicals and radium in agriculture and industry pose a risk to the environment and the general population. Awareness of these risks due to industrial waste has emerged through many cases of severe environmental impacts many years after disposal [25].

3. Synthesis of nanoparticles using different wastes

Agricultural wastes consist of both natural and nonnatural wastes such as bananas or oranges, wheat, straw, cotton or corn, coconut or almonds, silk, corn, oats, coconut oil, grapes, and empty grapes that can also be successfully applied to obtain nanoparticles [26]. On the other hand, industrial wastes have a wider variety and additional concentrated shape of hazardous materials needing special technologies and handling procedures for treatment of produced nano-materials [27].

3.1 Nano-cellulose

Nano-sized cellulose materials are currently made from agricultural wastes and involved in the durable materials industry. The main groups of nano-celluloses (NC) are two (1) nano-fibrillated cellulose (NFC) and (2) cellular nano-crystals (CNC). They are often referred to as second-generation renewable resources for oil products. Further attention has been paid to these materials due to their low density and high mechanical properties, renewability, and biogas characteristics [28]. Extraction of nano-cellulose from agricultural wastes is a promising substitute for waste treatment, and greater use of nano-cellulose in biological sciences is expected in the future [29]. Nano-cellulose has become an important topic for many research areas because of its renewable availability of biocides and many good properties [30]. In recent years, research on nanoparticles has led to many applications and focuses on the latest developments in the value of lingo-cellulosic biomass obtained from different agro-industrial crops as a source of NC, which include (i) the structure of lingo-cellulosic biomass and its effects on nano-cellulose properties and (ii) prebiological treatment and nano-cellulose extraction procedures [31]. Also, Banana bark is a type of waste that is a promising material for the production of nano-zulose. It characterizes nano-cellulose from the inner and outer layers of the pseudo-banana tree as a preliminary research strategy for designing mutant packaging material from banana nano-cellulose [27]. From industrial wastes, different alternative pathways for the production of nano-cellulose crystals have been studied due to this common acid. The hydrocarbon-producing process leads to many environmental issues such as wastewater generation and water use or access to products containing sulfur [32].

3.2 Metals and metal oxide nanoparticles

Metals and metal oxide nanoparticles can be synthesized and improved in its properties using different wastes. Fe_3O_4 nano-composites are synthesized using papaya leaves as lingo-cellulosic agricultural wastes using a simple thermal decomposition method [33]. It has been found that the development of NPs from different plant systems is cost-effective, environmentally friendly, easy, and exciting way to other procedures. The roots of the plants have preserved several minerals and food reserves. They also contain phenols, alkaloids, flavonoids, terpenoids, proteins, enzymes, carbohydrates, and other organic compounds. These metabolites play a key role in reducing metal ions in the desired NPs and also act as closing and stabilizing agents [34]. Based on the nontoxic nature of SiO_2NP from bamboo leaves, the researchers successfully synthesized 13.8 nm SiO_2NP as a source of silica, which they considered as a potential alternative for drug delivery and other medical applications [35]. The addition of banana peel extract to an alkaline solution of tetraethyl orthosilicate in ethanol, followed by calcination of the precipitate, resulted in 20 nm SiO_2NPs [36]. Sugarcane baggage was used for size control (TiO_2NPs). TiO_2 sol obtained from titanium tetra isopropoxide at pH = 4 was calcined at 200°C for 5 h, resulting in a TiO_2 powder gel [37]. Also, Mn_3O_4 nanoparticles can be synthesizes using banana peel extract which play a dual role in reducing $KMnO_4$ to Mn_3O_4 formation and preventing agglomeration of nanoparticles during preparation [38]. Tea wastes are used to synthesize hydrated aluminum nanoparticles. This porous nanomaterial is synthesized by co-precipitation between aluminum sulfate and NaOH in the presence of tea waste and anionic polyacrylamide. Maintained porous aluminum is used as an anionic exchange of fluoride with sulfate ions to neutralize drinking water [39]. Scientists have developed a unique method for the synthesis of high quality GO and reduced graphene oxide (rGO) sheets of various naturally available green wastes and carbon wastes, including animal wastes, vegetable wastes (leaves, wood, and fruit waste) and semi-industrial wastes such as newspaper [40]. Green synthesis of silver nanoparticles (AgNP), using agricultural waste, is low-cost and safe for nature and is environmentally friendly. Coconut shell extract (*Cocos nucifera*) is used to synthesize Ag NPs [41]. The SnO_2 and Ag nanoparticles were produced with a solution of nitric acid from a raw material obtained by leaching printed circuit boards. First, the tin oxide is squeezed from nitric acid solution by three different techniques: (1) normal heating, (2) microwave heating, and (3) ultrasonic treatment. Second, this precursor is transformed into tin oxide nanoparticles by furnace heat treatment. Third, hydrochloric acid is added to the nitric acid solution to cause precipitation of silver chloride. Fourth, silver chlorine is reduced to silver nanoparticles in ammonia solution, using glucose as a reducing and closing agent. The reduction reaction was performed by (i) normal warming, (II) microwave scavenging, and (III) ultrasound therapy [42].

3.3 Carbon nanoparticles

Nanocarbons were synthesized in different ways, Such as synthesis of carbon nanotubes from waste (disposable container made of polyester) using a reactor and heating system. In the reactor used, because of the high pressure and temperature above 700°C used along with the appropriate catalysts for different periods, all the materials lose their macroscopes and disperse into nanoparticles. [43]. Also, carbon nanotubes were obtained by monitoring pyrolysis of acrylic fiber residues under a layer of charcoal using physical activity in a high-temperature oven [44]. Carbon nanotubes can be released from nanoparticles into the environment at the end of their life, or whether they remain embedded in the matrix. Carbon nanotubes from poly lactic films and poly lactic acids were studied for the scenario of biodegradation and nano-composite [45]. Additionally, carbon nanoparticles synthesized by laser pyrolysis of hydrocarbons in a flow reactor have been studied as a function of laser energy [46]. On the other hand, waste plastic caused serious environmental problems. In this case, nitrogen-doped porous carbon nano-sheets (N-PCN) were prepared using magnesium hydroxide sheets [Mg (OH) 2], which are modified by Zn and Co bimetallic zeolite imidazolate frame nanoparticles such as templates and polystyrene (PS) as a carbon precursor [47]. Also, nano-channeled ultra-fine carbon tubes (NCUFCTs) and polygonal carbon nanotubes (MWCNTs) were prepared from polyethylene terephthalate (PET) waste by the spinning cathode technique. The manufacture of carbon black from anode covers ultra-fine and nano-sized solid carbon spheres (SCS) by means of an average diameter of 221 and 100 nm individually, shaped in the low-temperature area of the anode, where the temperature is around 1700°C [48]. Carbon-bound nanofibers (CNFs) are obtained by the decomposition of methane onto Ni nanoparticles supported by grooved SiC nanowires. In beam CNFs, several CNFs grow in parallel and form a packet of CNFs [49]. Tea wastes are rich in carbon, nitrogen, and potassium, but poor in phosphorus, which means that they can also be used to reduce metal oxides once they are carbonated and form carbon nanoparticles [50]. Also, thermoplastic polymers (such as polypropylene, polyethylene, polyvinyl chloride, polystyrene, etc.) are the main components of municipal solid waste. Millions of tons of plastic waste are dumped every year, most of which is incinerated or dumped. Alternatively, various researchers have proposed methods using this waste as feed to produce value-added products such as fuels, carbon nanotubes, and porous carbon emissions [51].

3.4 Silica and graphene nanoparticles

The production of silica nanoparticles by conventional processes is complex and takes place at very high temperatures. Silica nanoparticles of different sizes are obtained from plastic waste, disposable boxes, and water bottles by a simple method of carbothermal reduction [52]. Also, researchers developed an alternative use of some agricultural waste as potential sources of silicon that can be used for PV cells. This study examines the use of cassava periderm, corn stalk, and cob as new sources of silicon nanoparticles. Agro-based silicon nanoparticles are prepared by the modified sol-gel method and then reduced using magnesium to synthesize silicon nanoparticles [53]. A nano-composite material found on Ag nanoparticles and graphene oxide was considered for its electrical, optical, and physical properties. According to electron and atomic force microscopy data, the size of the nanoparticles obtained varies mostly from 60 to 100 nm. The permeability and electrical resistance of this material indicate higher optical transparency and electrical conductivity than in virgin graphene oxide [54]. Agricultural wastes as rice straw, rice husk, and leaves of bamboo delivered a simple method to silicon production. Several agricultural wastes are generated and disposed of indiscriminately in the environment and thus pose environmental challenges. This study examines the use of cash periderm as a new source of silicon nanoparticles. The cassava was treated with acid before and after fermentation to obtain silicone residues for the gelation process for the production of silicon nanoparticles [55]. The synthesis of silica from nanoparticles from rice husk, sugarcane, and coffee nut has been reported using vermicompost with Anelides (*Eisenia foetida*). The product (humus) is calcined and extracted to recover the crystalline nanoparticles [56].

4. Environmental applications of produced nanoparticles using different wastes

Pollution is one of the biggest problems in the world, which poses a lot of risks to humans, animals, plants, and ecosystems [57]. Nano-cellulose has a diameter usually <10 nm, which gives it many unique properties. Among many others, these properties include high mechanical strength, large area, and low visual light scattering [58]. The four main groups of cellulosic nanoparticles and their easy surface modification provide a huge variety of new materials, composites, films, and gels with captivating and controllable properties to solve environmental problems and challenges [59]. Applications and properties of cellulosic nanoparticles such as adsorbent, photocatalyst, flocculant, and membranes have been reviewed in particular [60]. Attractive properties facilitate the use of nano-cellulose aerogels in various environmental and engineering applications such as water purification, filtration, flame retardation, and oil extraction [61]. The nano-cellulose has become a sustainable and successful nanomaterial with its unique structure and features such as high specific modulus, excellent stability in most solvents, low toxicity, and natural diversity. Eco-friendly environment, low cost, convenience, and simple synthesis techniques make nano-lotus a promising candidate for the production of green renewable energy storage [62]. Environmental challenges that can be addressed by the use of metal oxide nanoparticles that are produced by different wastes include removal of toxic chemicals such as different heavy metals from industrial wastewater and wastewater, catalysts for organic reactions to produce essential organic material, reproducible genes for environmental restoration, volatile organic compounds and detectors, and biological/chemical signals [63]. Catalysts of metal oxide nanoparticles include reaction-base, selective oxidation, complete oxidation, depolation, biosynthesis, green chemistry, and photocatalysis. Iron oxide nanoparticle catalysts are important components in the refining and petrochemical processes. These catalysts are also important for improving environmental quality [64]. On the other hand, graphene and carbon tube nanoparticles offer a variety of advanced applications in the field of energy storage, biological applications, and electrolytes due to their mechanical, electrical, electrical, and thermal properties [65]. Nanocarbon-TiO_2 composites were prepared by the liquid phase deposition method to apply as photocatalytic for the degradation of heavy metals, diphenhydramine, and dyes [66].

5. Conclusion

This chapter concluded that, millions of tonnes of different wastes are produced annually without any benefits from it. Researchers have used these wastes in synthesis of different nanoparticles such as nano-cellulose, metals, and metal oxide nanoparticles, carbon nanoparticles and nano-fibers by different methods. These NPs are used to solve environmental problems, especially pollution, for which they are used as protective agents and adsorbents. In future prospective, researchers must use these NPs in a wide range of applications as ecofriendly and low-cost products.

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Conflict of interest

The authors declare no conflict of interest.

Author details

Salah Abdelbary[1]* and Hadeer Abdelfattah[2]

1 Botany and Microbiology Department, Faculty of Science, Al-Azhar University, Nasr City, Egypt

2 Drug Radiation Research Department, Atomic Energy Authority, Nasr City, Egypt

*Address all correspondence to: salah.micro87@gmail.com

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