A Review of Strategies for Using Pistachio Waste

Reza Ali Fallahzadeh (PhD)[1], Motahare Tahmasebimoradi (BS)[1], Najmeh Soltani Gerdefaramarzi (BS)[1], Pouriya Torabidost(BS)[1], Hadi Eslami (PhD)[2*]

[1]*Genetic and Environmental Adventures Research Center, School of Abarkouh Paramedicine, Shahid Sadoughi University of Medical Sciences, Yazd, Iran*

[2]*Department of Environmental Health Engineering, School of Health, Occupational Safety and Health Research Center, NICICO, World Safety Organization and Rafsanjan University of Medical Sciences, Rafsanjan, Iran*

Information

Article Type:
Review Article

Article History:

Received:17.01.2021
Accepted:12.03.2021

Doi:
10.22123/PHJ.2021.281700.1094

Keywords:
Pistachio waste
Compost
heavy metals
pistachio

Corresponding Author:
Hadi Eslami

Email:hadieslami1986@yahoo.com

Tel: +98-9177094695

Abstract

Introduction: Iran is one of the largest producers of pistachios in the world. The development of pistachios and related industries has created various conditions and opportunities for the expansion of agricultural and industrial activities as well as environmental issues. The researches show that only 35% of the weight of fresh pistachios is comprised of dried pistachios, so pistachio processing produces a large amount of pistachio waste, which can cause widespread environmental pollution if not managed properly.

Materials and Methods: This is a review study that examines the methods of using pistachio waste in previous studies. This research is conducted by searching keywords in Scopus, web of sciences and other Iranian scientific and research databases.

Results: The findings of this study showed that most of the studies conducted on pistachio waste have investigated three areas of removal of pollutants from aquatic environments by surface adsorption process, biogas and biofuel production and compost production. According to studies, pistachio shell powder and activated carbon produced from pistachio shell can remove cyanide, heavy metals and dyes from aquatic environments.

Conclusion: The management of waste resulting from pistachio processing industries can reduce the threat of environmental pollution and help to control pollution, remove pollutants from the environment, increase agricultural productivity and earn income from products. Pistachio waste can be used more in three areas of pollutant absorption, biogas production and compost.

►Please cite this article as follows:

Fallahzadeh RA, Tahmasebimoradi M, Soltani Gerdefaramarzi N, Torabidost P, Eslami H. A Review of Strategies for Using Pistachio Waste. Pistachio and Health Journal. 2021; 4 (1): 86-95.

1. Introduction

The agricultural sector has always played a significant role in non-oil exports and foreign exchange earnings of the country. Pistachio has been one of the major export products of agricultural sector, so that currently the export of this product ranks first among the exports of other goods in this sector. Pistachio processing industry has also increased significantly in line with the development of pistachio fields [1]. Extensive development of human societies is achieved through scientific development in various dimensions such as industrial, agriculture, medicine, and health development. Waste is generated in all of these development sectors. If generated waste is not managed, it can cause widespread environmental pollution and threaten human societies. Extensive studies are conducted on the management of pollution produced by these wastes [2], and on the reuse and recovery of wastes [3]. One of the dimensions of progress is the development of agriculture and related industries. In addition to agricultural development, the management of waste generated from this industry is also very important and vital, and if it is not managed properly, it can cause widespread environmental pollution, especially groundwater pollution [4]. Statistics in Iran show that almost half of agricultural products are wasted in various stages. In Iran, conversion industries have not reached the level of growth that can fully use all components of an agricultural product. In Iran, the pistachio crop has about 135,000 tons of waste annually, which can be converted to more valuable materials having a detailed plan, using new technologies and organizing them, as they are the basis of environmental issues [5] In the country's farms, agricultural wastes are significant. In other countries, agricultural waste is the main source of supplying materials for exporting to other countries. In many developing countries, agricultural by-products have a higher value and sometimes the value of some of these materials is much higher than the main product [6].

One of the largest producers of pistachios in the world is Iran [7, 8]. The development of pistachios and related industries has created various conditions and opportunities for the expansion of agricultural and industrial activities as well as environmental issues [9]. The researches show that only 35% of the weight of fresh pistachios is comprised of dried pistachios, so 25 -75% of the pistachio crop consists of green shell, clusters, and hollow and unripe fruits. These wastes are added to the soil as organic fertilizer or dumped near pistachio collection terminals[10].

Pistachio (L. vera pistachia) belongs to the Anacardiaceae family, and in recent years, a high percentage of pistachio waste is produced and caused environmental problems. Large amounts of mixed pistachio waste are used as agricultural residues during peeling and are sometimes mixed with soil and used as animal feed. There are a lot of phenolic compounds in pistachio green shell, so using pistachio green shell as a phytochemical material increases the production value of pistachios and regarding the large volume of these wastes, they can be used as a rich source of polyphenols [11].

Thousands of tons of green waste are produced annually, including perishable waste, horticultural and green space waste, and waste from agricultural conversion industries, causing irreparable damage when released in the environment, so proper management of agricultural waste is important [10]. According to FAO statistics, one of the largest producers of

pistachios in the world is Iran, which produces 85% of world pistachio. Pistachio wastes contaminate pistachio orchards with Aspergillus fungi, and the release of annoying odors and the growth and multiplication of flies occur following the release of these wastes into the environment. On the other hand, with the burial of pistachio shell in pistachio orchards by farmers, due to the unstable organic materials in pistachio shell, the roots are damaged and plant growth stops. Rapid perishability of pistachio shell causes health problems and environmental pollution, so it is necessary to dispose it in a proper, hygienic and economic way [12].

In conversion industries, pistachio peeling wastes have many uses; for example, a substance called furfural is produced from it, which is used in the pharmaceutical industry and is expensive in world markets. The waste of bone shell of pistachio is used in the production of activated carbon used in the food industry, and the green shell of pistachio is used for preparing carpet weaving and dyeing fibers. It is also possible to use pistachio green shell to make a substrate for preparing edible mushrooms that have a high efficiency [6, 13]. Pistachio nuts lesions include small, spotted, pest-infected, bird-knocked pistachios, and pistachios sampled for aflatoxin testing; and oil can be extracted from these wastes using appropriate equipment. These pistachio wastes can also be used to produce biogas [6]. The purpose of this study is to review the articles on pistachio processing wastes and summarize them in a review article.

2. Materials and Methods

To conduct this study, the key words including "pistachio, pistachio waste, pistachio residue, pistachio processing" published between 2010-2020 were searched in Scopus, web of sciences and other Iranian scientific and research databases including Scientific Information Database (SID) and (ISC) Islamic World Science Citation Center. Unrelated articles without full file access were then removed and 25 articles were selected. Finally, after studying the articles, the methods of reusing pistachio waste were extracted in the form of sections that will be presented below.

3. Result

A review of previous studies showed that most studies are conducted on the use of pistachio waste in three areas of removal of pollutants from aquatic environments by adsorbents produced from pistachio waste, biogas and biofuels production and compost production. In the following, we will review the studies conducted on these three areas.

1. Using wastes as a pollutant adsorbent:

So far, various methods have been proposed to remove pollutants from different environments. One of the methods used widely to remove various pollutants, especially from aquatic environments, is the use of adsorption process. So far, many natural and synthetic adsorbents have been proposed to remove various pollutants, especially stable pollutants such as heavy metals. Among these, natural adsorbents have been studied and used more due to the simplicity of the production process and availability [14]. Raw agricultural waste is a cheap adsorbent for the removal of industrial pollutants. Pistachio waste is used as a pollutant adsorbent in various industries. The following part is about some studies conducted on the removal of some selected pollutants.

2-1. Removal of Chromium:

Environmental pollution, especially groundwater pollution with heavy metals such as

chromium is one of the problems and concerns of human beings [15-17]. In one study, pistachio shell powder was tested to remove hexavalent chromium (Cr (VI)) from wastewater. In this study, the variables such as pH, pistachio powder concentration, chromium (VI) concentration, temperature and contact time were investigated for the removal of chromium (VI) from aquatic solution. The results showed that pistachio shell powder is able to absorb more than 99% of chromium from solutions containing 50-200 mg/l chromium (VI) at pH 2 and adsorbent concentration of 5 g/l after 60 minutes. The percentage of chromium absorbed from the solution increased with increasing temperature from 5 to 40 ° C. Using pistachio shell powder as an adsorbent is a cost-effective and simple process for the treatment of industrial wastewater containing chromium (VI) [18].

3-1. Phenol removal:

Phenol causes an unpleasant taste and odor in aquatic resources. In drinking water containing chlorine, phenol forms compounds such as chlorophenol, which have a medicinal taste which is distinct and undesirable. Phenol also causes cancer and significant health problems for humans, even at low concentrations. These compounds cause damages to sensitive cells due to their toxic effects such as cytoplasmic coagulation, thus causing health, environmental and irreversible problems. To remove phenol, the adsorption process is the simplest, fastest, the most effective, and the most economical method. Inexpensive and available adsorbents such as agricultural waste are used to remove phenol. One of the adsorbents used is activated carbon. Adsorption of phenol from aquatic solutions is done using activated carbon from pistachio shell wastes. It should be mentioned that pistachio wastes have a high tendency to absorb phenol [3].

4-1. Removal of Industrial Dyes:

Dyes are one of the most dangerous groups of chemical compounds in industrial effluents that reduce the possibility of light transmission and consequently disrupt the process of photosynthesis in aquatic resources [19, 20]. Also, aesthetically, they have a negative effect on water quality for various uses and cause allergies, dermatitis, skin irritation, cancer and genetic mutations in humans [19]. Removal of synthetic dyes from industrial effluents through the adsorption process is the most efficient method; on one hand, the dyes in wastewater are easily transferred to the solid phase; and on the other hand, the adsorbent can be regenerated and reused in the adsorption process [21]. Also, due to the minimum investment costs, ease of design and operation and lack of sensitivity to toxic compounds, the adsorption process is a reliable treatment solution [22]. Activated carbon is used as an adsorbent to treat wastewater. Using inexpensive materials such as agricultural and industrial residues is an effective method for producing activated carbon [23]. On one hand, converting agricultural waste into inexpensive adsorbents and solving the biomass problem will increase the value of agricultural waste. The advantages of carbon derived from agricultural wastes include low ash content, reasonable hardness, high cross-section and sufficiently porous structure. Waste of pistachio processing has a high ability to absorb different dyes [4].

Moussavi et al., analyzed pistachio shell powder produced from agricultural waste as a new adsorbent for the removal of dye molecules from contaminated streams. Removal of methylene blue (MB) as a cationic model dye by pistachio shell powder from aquatic solution was

studied under various experimental conditions. The selected parameters were pH of solution, pistachio powder concentration, MB concentration, contact time and solution temperature. Experimental results showed that maximum MB removal could be achieved in solution pH 8. The dose of pistachio powder was also an important variable that affects the percentage of MB removal. Thermodynamic evaluation of MB adsorption on pistachio shell powder showed that the adsorption phenomenon under selected conditions is a spontaneous physical process. Accordingly, pistachio shell wastes are a highly efficient, inexpensive adsorbent and a promising alternative for removing dyes from industrial wastewater [24].

5-1: Removal of Cyanide:

Many wastes are evaluated in terms of their efficiency in removing various types of contaminants from water and wastewater to improve the cost-effectiveness of adsorption. In the study conducted by Mousavi et al., pistachio green shell waste was investigated as a potential adsorbent for cyanide removal from synthetic wastewater. The effects of selecting the most important parameters (pH, adsorbent dose, cyanide concentration and contact time) were initially evaluated based on the percentage of cyanide removed from the wastewater. At an optimum pH of 10, more than 99% removal of 100 mg/L cyanide was obtained for an adsorbent dose of 1.5 g/L after contact time of 60 minutes. The study of adsorption of cyanide ions on the introduced adsorbent showed that a chemical adsorption process with intraparticle diffusion is the most important factor in controlling the process speed. Therefore, pistachio shell waste can be used as an efficient and inexpensive adsorbent to remove different concentrations of cyanide from water and wastewater [25].

6-1. Removal of Nickel:

Heavy metals are the elements and materials abundant in industrial wastewaters and cause environment and nature pollution. Agricultural waste is an effective sorbent for the removal of heavy metals. The adsorption behavior of pistachio shell powder to remove nickel (II) ions as an inexpensive and cost-effective adsorbent is investigated in the study conducted by Beidokhti et al. The parameters studied were pH of solution, initial metal concentration, adsorbent concentration in suspension and process time. The optimum pH for the maximum absorption was 4-6. The initial concentration of adsorbent and the concentration of pistachio shell strongly affect the process. To treat wastewater from heavy metals, the adsorption of nickel on pistachio shell was investigated and according to the results of experiments, pistachio shell powder produced from agricultural waste was introduced as an inexpensive and efficient adsorbent for the biological removal and adsorption of nickel (II) from aquatic solutions in water and wastewater [26].

7-1. Removal of Cadmium and Lead:

Hamidpour et al. used raw pistachio shell powder to remove cadmium (II) and lead (II) from aquatic solutions. Experiments showed that the biological adsorption of cadmium (II) and lead (II) on the adsorbent is fast and the maximum biological adsorption capacity was achieved in 2 hours. The adsorption of cadmium (II) and lead (II) equilibria was satisfactorily described by the Sips isotherm. Adsorption isotherms showed that the tendency of cadmium (II) and lead (II) to the adsorbent increased with increasing pH. FTIR results confirmed the presence of reactions between metals and functional groups on the surface of pistachio shell. These findings showed that the raw

pistachio shell powder used in this study has a high adsorption capacity for cadmium (II) and lead (II), so this adsorbent can be used to remove these metals from contaminated sites [27]

8-1. Removal of Copper:

In recent years, biochar has been widely used as an effective and inexpensive bioadsorbent in water and wastewater treatment processes. Different biomass can be used effectively to produce biochar. Jalayeri et al. studied the use of a new biochar obtained from pistachio green shell to remove Cu (II) from aquatic solutions. Analysis of experimental results showed that biochar obtained from pistachio green shell can be used as a green and cost-effective adsorbent to remove copper (II) from water [28].

2. Use of waste as biodiesel and green fuel

Biomass is a renewable energy source which is sustainable and environmentally friendly [29] Considering about 30% of agricultural waste in Iran and also the importance of the processing industry in reducing waste, biomass such as pistachios is very significant. Studies show that the fermentation and pyrolysis processes of pistachio waste produce valuable fuels [30]. In addition, the biological digestion process can be performed on freshly harvested pistachio wastes. There is considerable potential for using agricultural residues, especially pistachios as fuel in Iran. Biogas production from soft pistachio shell, and decomposition due to heating hard pistachio shell is the most effective way to dispose waste, produce fuel and use them optimally [31]. Using anaerobic fermentation, 103.5 million cubic meters of biogas can be obtained from pistachio waste. The potential of 47.6 million liters of ethanol production from total pistachio waste can be predicted. The use of pistachio waste, in addition to economic benefits for investors, will have positive environmental effects [32].

Çelik et al. investigated the anaerobic treatment capability and potential of biogas production from pistachio wastes. The results showed that anaerobic digestion of pistachio shell wastes and subsequent biogas production as a renewable energy source is possible. Based on the results, the highest yield of methane production was observed at 213.4 ml CH4/g COD [33].

3. Using Waste in Compost Production

Preparation of humus-containing organic material called compost is one of the methods of recycling organic waste such as household waste, sewage sludge, agricultural waste, which is done by aerobic or anaerobic microorganisms and by changing these materials, which prevents the spread of many diseases in society, prevents contamination of groundwater aquifers, increases humus for the quality of agricultural soils and make the environment beautiful [34].

The use of biochar in agricultural lands to provide organic material for plant growth and as a modifier to improve soil properties can be a useful solution for organic waste management due to its high durability [35]. Proper use of agricultural waste is one of the important strategies for sustainable development of the agricultural sector in Iran (34, 36). Composting is one of the methods of managing pistachio processing waste [37]. Pruning of pistachio branches annually leads to large amounts of waste, which is usually burned to prevent the spread of pests. Preventing the burning and optimal use of these wastes compensates for the lack of soil organic matter and prevents environmental pollution. Biochar can improve the morphophysiological properties and concentrations of essential elements such as

phosphorus and potassium in the aerial organ of the safflower plant. By improving the nutritional status of these elements in the soil and also increasing the soil water holding capacity due to the high content of organic carbon in the soil, biochar can provide a better environment for plant growth and thus improve growth indices [38].

Nowadays, adding biochar to soils has attracted attention as a suitable solution for carbon sequestration in soil and reducing the concentration of carbon dioxide in the air. In addition, biochar as a suitable improver can help improve the physical and chemical properties of soil. Researches have shown that using biochar in the soil increases the cation exchange capacity and soil water holding capacity, as well as the gradual release of limiting elements in the soil [39].

Esmaeili et al., investigated a composting process - preparation of vermicompost with Eisenia fetida for the treatment of pistachio waste mixed with cow manure in a different proportion. This process was performed in two stages of pre-composting and vermicompost and physicochemical parameters and worm growth ratio were measured and compared in different treatments. The results showed that the blending process significantly increases the quality of the final product and the fertilizer produced is homogeneous, granular, odorless and rich in nutrients. Physico-chemical analysis showed a significant decrease in the ratio of C: N, total organic carbon, and total potassium, and an increase in total nitrogen, available phosphorus, and pH. Therefore, the combined compost-vermicompost process can be an effective method for managing pistachio and CD waste [40].

Shirani et. al., conducted a study to investigate the effect of pistachio waste on the physical properties of two soil types (silty clay loam and sand). The results showed that the penetration resistance in both soil types was reduced by using pistachio wastes and the soil water holding capacity was increased [41].

4. Conclusion:

The review of studies in this regard showed that most studies are conducted on three areas of removal of pollutants from aquatic environments such as heavy metals, cyanide, various dyes through adsorption on pistachio shell powder and activated carbon produced from pistachio waste, biogas and biofuels produced from pistachio processing waste as well as compost production from pistachio waste. Industrialization of pistachio waste in the studied areas can control the entry of large volumes of chemical and biological pollutants into the environment and play an important role in increasing the well-being and improving the quality of agriculture and related industries.

References

1- Fallahzadeh RA, Eslami H. Pistachio Waste Management for Sustainable Development. Pistachio and Health Journal. **2019**;*2(2):57-60*.

2- Fallahzadeh RA, Gholami M, Madreseh E, Ghaneian MT, Farahzadi MH, Askarnejad AA, et al. Comparison of Using an Electronic System and Conventional Monitoring Method for Monitoring the Quality of Drinking Water and Defects Discovery in Rural Area Water Distribution Network of Abarkouh, Iran. Health. **2015**;*7:35-40*.

3- Ghaneian MT, Tabatabaee M, Ehrampoush MH, Jebali A, Hekmatimoghaddam S, Fallahzadeh H, et al. Synthesis of Ag (I) and Cu (I) complexes with 4-Amino-5-Methyl-2h-1, 2, 4-Triazole-3 (4h)-thione ligand as thiocarbohydrazide derivatives and their antimicrobial activity. Pharmaceutical Chemistry Journal. **2015**;*49(3):210-2*.

4- Eslami H, Almodaresi S, Khosravi R, Fallahzadeh R, Peirovi R, Taghavi M. Assessment of groundwater quality in Yazd-Ardakan plain for agricultural purposes using Geographic Information System (GIS). Journal of Health. **2018**;*8(5):575-86*.

5- Poorjafari A, Goltapeh EM, Noushabadi MA. Evaluating on possibility use of pistachio waste in composition substrate of white button mushroom. Journal of Crop Improvment. **2017**;*19(1):43-53.*

6- Nguyen, H., Moghadam, M. J., & Moayedi, H. Agricultural wastes preparation, management, and applications in civil engineering: a review. Journal of Material Cycles and Waste Management, 2019;21(5): 1039-1051.

7- Fallahzadeh RA, Eslami H. Electro-Oxidation as an Effective Technology in Removal of Persistent Organic Pollutants of Wastewater from Processing Pistachios. Pistachio and Health Journal. **2020**;*3(3):1-5*.

8- Fallahzadeh RA, Eslami H, Eshaghpanah MS. A Review of Applied Disinfection Methods in Foods Industry and Pistachio Processing. Pistachio and Health Journal. **2020**;*3(1):32-44*.

9- Fallahzadeh RA, Eslami H, Eshaghpanah MS. A Comparison of Pistachio Trees and Atriplex Vegetation in Reducing Leishmaniasis .Pistachio and Health Journal. **2019**;*2(4):43-52*.

10- Daneshmandi MS. Application of PistachioWaste as Organic Manure in Sustainable Agriculture. Journal of Agricultural Science and Sustainable Production. **2017**;*27(1):217-26.*

11- G. F, M A. Extraction of Phenolic Compounds from Pistachio Processing Unit Effluent by Developed Microemulsion Liquid Membrane as a Nanocareer. Electronic Journal of Food Processing and Preservation. **2014**;*5(1):61-79.*

12- Rezaei M, Karimi F, Parviz M, Behzadi AA, Javadzadeh M, Mohammadpourfard I, et al. An empirical study on aflatoxin occurrence in nuts consumed in tehran, iran 2013. Health. **2014**;*6(08):649*.

13- Siddiqui SH, Ahmad R. Pistachio Shell Carbon (PSC)–an agricultural adsorbent for the removal of Pb (II) from aqueous solution. Groundwater for Sustainable Development. **2017**;*4:42-8*.

14- Crini G, Lichtfouse E, Wilson LD, Morin-Crini N. Conventional and non-conventional adsorbents for wastewater treatment. Environmental Chemistry Letters. **2019**;*17(1):195-213*.

15- Fallahzadeh RA ,Khosravi R, Dehdashti B, Ghahramani E, Omidi F, Adli A, et al. Spatial distribution variation and probabilistic risk assessment of exposure to chromium in ground water supplies; a case study in the east of Iran. Food and chemical toxicology. **2018**;*115:260.6-*

16- Fallahzadeh RA, Ghaneian MT, Miri M, Dashti MM. Spatial analysis and health risk assessment of heavy metals concentration in

drinking water resources. Environmental Science and Pollution Research. **2017**;*24(32):24790-802.*

17- Arghavan FA, Khosravi R ,Taghizadeh AA, Taghavi M, Entezari A, Khazaei M, et al. Investigation of chromium removal efficiency from aqueous solution using of powdered activated carbon produced using ultrasonic waves. Journal of Birjand University of Medical Sciences. **2016**;*23(3):235-245.*

18- Moussavi G, Barikbin B. Biosorption of chromium (VI) from industrial wastewater onto pistachio hull waste biomass. Chemical Engineering Journal. **2010**;*162(3):893-900*.

19- Eslami H, Sedighi Khavidak S, Salehi F, Khosravi R, Fallahzadeh R, Peirovi R, et al. Biodegradation of methylene blue from aqueous solution by bacteria isolated from contaminated soil. J Adv Environ Health Res. **2017**;*5(1):4-6.*

20- Fallahzadeh R, Ghaneian M, Dehvari M, Mahdavifar R. Treatment of synthetic wastewater containing reactive blue 19 by electrolysis process. Alborz University Medical Journal. **2014**;*3(2):109-14.*

21- Miri M, Fallahzadeh RA, Ghaneian MT, Gholami M, Mahdavifar R, Shahriyari AR. The efficiency of residues of rosa damasena powder in removing reactive red 198 Dye from synthetic textile effluent. Journal of Environmental Health Enginering. **2014**;*1(4):271-80*.

22- Miri M, Ghaneian M, Shahriari Farfani A, Fallahzadeh R. Effectiveness of rosewater waste in de-colorization of reactive Blue 19 from synthetic textile wastewater. Journal of Health Research in Community. **2015***;1(4):28-36.*

23- Fallahzadeha RA, Ehrampoushb MH, Meybodic MN, Ghaneianb MT, Dalvandb A, Omidid F, et al. Investigating the effect of photo-electro oxidation process modified with activated carbon bed as a porous electrode on amoxicillin removal from aqueous solutions. DESALINATION AND WATER TREATMENT. **2020**;*185:185-95*.

24- Moussavi G, Khosravi R. The removal of cationic dyes from aqueous solutions by adsorption onto pistachio hull waste. Chemical Engineering Research and Design. **2011**;*89(10):2182-9.*

25- Moussavi G, Khosravi R. Removal of cyanide from wastewater by adsorption onto pistachio hull wastes: Parametric experiments, kinetics and equilibrium analysis. Journal of Hazardous Materials. **2010***;183(1-3):72.30-4*

26- Beidokhti MZ, Naeeni STO, AbdiGhahroudi MS. Biosorption of nickel (II) from aqueous solutions onto pistachio hull waste as a low-cost biosorbent. Civil Engineering Journal. **2019**;*5(2):447-57*.

27- Hamidpour M, Hosseini N, Mozafari V, Rafsanjani MH .Removal of Cd (II) and Pb (II) from aqueous solutions by pistachio hull waste. Revista Internacional de Contaminación Ambiental. **2018***;34(2):307-16*.

28- Jalayeri H, Pepe F. Novel and high-performance biochar derived from pistachio green hull biomass: production, characterization, and application to Cu (II) removal from aqueous solutions. Ecotoxicology and environmental safety. **2019**;*168:64-71*.

29- Kasiri N, Fathi M. Production of cellulose nanocrystals from pistachio shells and their application for stabilizing Pickering emulsions. International journal of biological macromolecules. **2018**;*106:1023-31*.

30- Ahanchi M, Tabatabaei M, Aghbashlo M, Rezaei K, Talebi AF, Ghaffari A, et al. Pistachio (Pistachia vera) wastes valorization: enhancement of biodiesel oxidation stability using hull extracts of different varieties. Journal of Cleaner Production. **2018**;*185:852-9.*

31- Okutucu C, Duman G, Ucar S, Yasa I, Yanik J. Production of fungicidal oil and activated carbon from pistachio shell. Journal of

analytical and applied pyrolysis. **2011**;*91(1):140-6*.
32- Taghizadeh-Alisaraei A, Assar HA, Ghobadian B, Motevali A. Potential of biofuel production from pistachio waste in Iran. Renewable and Sustainable Energy Reviews. **2017**;*72:510-22.*
33- Çelik İ, Demirer GN. Biogas production from pistachio (Pistacia vera L.) processing waste. Biocatalysis and Agricultural Biotechnology. **2015**;*4(4):767-72*.
34- Jalili M, Ebrahimi A, Karimi H, Mokhtari M. Survey the effect of pistachio waste composting process with different treatments on concentration of heavy metals. Toloo-e-Behdasht. **2016**;*15(3):103-14.*
35- Dehvari M, Committee SSSR. Physical-Chemical Analysis and Comparison with Standards of the Compost Produced in Sanandaj, Iran. Open Access Library Journal. **2015**;*2(10):1.*
36- Jalili M, Mokhtari M, Eslami H, Abbasi F, Ghanbari R, Ebrahimi AA. Toxicity evaluation and management of co-composting pistachio wastes combined with cattle manure and municipal sewage sludge. Ecotoxicology and Environmental Safety. **2019**;*171*:*798-804.*
37- Jalili M, Ebrahimi A, Karimi H, Mokhtari M. Survey the Effect of Pistachio Waste Composting Process with Different Treatments on Concentration of Heavy Metals. Tolooe Behdasht. **2016**;*15(3):103-14*.
38- Arab Bafrani Z, Ghanei-Bafghi M-J, Shirmardi M. Effect of wood residues of pistachio biochar on growth characteristics of Safflower. Journal of Soil Management and Sustainable Production. **2020**;*10(3):73-94.*
39- Khademi Jolgenejad A, Fekri M, Mahmoodabadi M. The effect of different pistachio wastes biochar application on some fertility properties of a loam soil .Iranian Journal of Soil and Water Research. **2019**;*50(1):231-46*.
40- Esmaeili A, Khoram MR, Gholami M, Eslami H. Pistachio waste management using combined composting-vermicomposting technique: Physico-chemical changes and worm growth analysis. Journal of Cleaner Production. **2020**;*242:118523.*
41- Shirani H, Rizahbandi E, Dashti H, Mosaddeghi MR, Afyuni M. Effect of Pistachio Waste on Some Soil Physical Characteristics and Compactability of Two Soil Types. JWSS-Isfahan University of Technology. **2011**;*15(55):85-98.*