

## Heavy metals in pistachio peel compost

Reza Ali Fallahzadeh(PhD)<sup>1\*</sup>, Omolbanin Nateghi(BSc)<sup>1</sup>, Farnaz Istadeh(BSc)<sup>1</sup>

<sup>1</sup>*Genetic and Environmental Advantages Research Center, School of Abarkouh Paramedicine, Shahid Sadoughi University of Medical Sciences, Yazd, Iran.*

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The production of agricultural waste has been increasing with the development of the agricultural economy in recent years. These wastes can cause problems for the environment as well as humans [1]. According to the Food and Agriculture Organization (FAO), Iran is the largest producer of pistachios in the world, and in recent years, the total pistachio by-products in Iran have increased by nearly 310 thousand tons and have caused many environmental problems [2]. Pistachio peel is one of the by-products of pistachio processing. Pistachio peel is classified as agricultural waste, and the discharge of these substances into the environment causes the release of annoying odors and the growth and reproduction of flies. Moreover, most farmers bury pistachio peel in pistachio orchards. Since pistachio peel contains unstable organic matter, it damages the roots of the plant and stops its growth [3]. Many pistachio by-products are best used as animal feed. However, pistachio waste has a high level of polyphenolic compounds and phenolic compounds that cause the adhesion of proteins, carbohydrates, and minerals in the digestive tract of living organisms, the high consumption of these compounds is highly toxic [4].

Composting is an aerobic process and involves approaches that are used to treat, control, and manage various types of waste (such as sewage sludge, municipal waste, agricultural organic waste, etc.) that can be biologically treated [5]. Thus, composting can be a useful option for using these wastes due to the biological deformation of the wastes, which eliminates their potential risks and the final product improves the soil quality. Composting or adding compost can simultaneously increase soil organic matter content and soil fertility. Thus, composting is one of the most cost-effective ways to improve soil quality [6].

One of the main limitations of using compost is the presence of heavy metals. High concentrations of heavy metals are considered toxic to the soil, plants, aquatic life, and human health, as they accumulate in the soft tissues of the body due to their inability to metabolize [7]. Heavy metals are often found as pollutants in green waste. Any waste that is subsequently segregated for composting has the potential to retain this possible contamination. The leakage of heavy metals from compost leads to the accumulation of elements in the soil layers and, as a result, contamination of groundwater [8].

Elements such as zinc, copper, nickel, cadmium, lead, chromium, and mercury are a concern when using compost in the soil because they are more abundant in the compost than they are in the soil, and heavy metal concentration increases due to loss of volatile solids, and decomposition of organic matter during the composting process [9].

Heavy metals, when used in high concentrations, have the potential for plant toxicity and geotoxicity [10]. Accumulation of large amounts of heavy metals in the soil causes their transfer to the food chain,

which also affects human health. Besides, exposure to heavy metals can cause problems such as blood and bone disorders, kidney damage, reduced mental capacity, and nerve damage [11].

many countries have defined standards for the concentration of heavy metals in compost to prevent soil and groundwater contamination by compost. For example, the maximum standard concentrations in the Netherlands for Pb, Cu, Zn, Cd are 65, 25, 75, and 0.7, respectively, and the standard concentrations are 400, 100, 150, and 1.5 for Germany [5]. Increased lead in the body causes lead poisoning (saturnism) which causes blue lines on the gums [12]. Zinc is also toxic in doses higher than 3 mg/L in water and causes slow growth in children, reduced fertility, dry mouth, nausea, and headache [13]. According to WHO guidelines, the concentrations of zinc required in children, men, and women are 5, 15, and 12 mg per day, respectively, and the global average lead absorption in adults is 200 micrograms per day [14]. Cadmium is of special importance among heavy metals due to its high toxicity (2 to 20 times as much as other heavy metals [15]) and long half-life in humans and animals. This element causes failure of the liver, lungs, bones, blood circulation, heart, and vital organs such as the brain and kidneys, and has adverse effects on human intelligence.

Therefore, careful monitoring of the concentrations of heavy metals in compost is essential for normal monitoring and risk assessment as well as environmental protection [17]. So far, various studies have addressed the concentrations of heavy metals in compost in different parts of the world. Guerra-Rodríguez et al. assessed the concentration of heavy metals in the compost and showed that the contents of zinc, cadmium, lead, and copper are each at the highest standard level [18]. Ayari et al. (2010) also measured lead, nickel, cadmium, and zinc and reported that the concentration of heavy metals such as nickel, cadmium, and lead was lower than the standard, and zinc content was higher than the environmental standard [14]. Ahmadi Mousavi and Ataei (2017) investigated heavy metals concentration in vermicomposting of the soft peel of pistachio, municipal activated sludge, and spent mushroom compost and showed that copper concentration increased in all final treatments. The highest concentration of copper was 2.36 ppm, while the concentration of nickel decreased and the highest value was 0.021 ppm. Concentrations of lead, zinc, and cadmium also decreased in some treatments and increased in other. The data also showed that the concentration of heavy metals is within the allowable range and the use of vermicomposting in agriculture will not have harmful effects [19].

In their cross-sectional descriptive study, Yazdani et al. assessed heavy metals in the compost produced by the pistachio hull and livestock waste and found that the maximum concentration of metals in the sample was 246.5 for lead, 11.4 for cadmium, 96.4 for chromium, 121 for copper, 200.4 for zinc, and 141.4 mg/kg dry weight for nickel. The results of this study showed that in some cases the quality of pistachio peel compost was outside of the range of Iranian compost standard [5].

Failure to pay attention to the concentrations of heavy metals in pistachio peel compost can increase these contaminants in the soil, which leads to the accumulation of these substances in agricultural products and their transfer to the food chain. Thus, evaluating the concentrations of heavy metals in compost fertilizer is essential as a health parameter. Moreover, effective measures should be adopted to reduce heavy metals in compost fertilizers.

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