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A Life Cycle Assessment: The Use of Sewage Sludge in Ornamental Plant Growing

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Today, the amount of the sewage sludge coming from domestic and industrial waste water which appear due to population increase, industrialization and urban growth has reached a level that is threatening human health and the environment. It is of crucial importance that the sewage sludge is removed with environmental-friendly methods for the protection of the environment. In this scope, the waste water sewage sludge is used in agricultural areas, forest areas, parks-gardens, recreational grounds, recreation of areas, urban landscaping as well as in arboriculture, and in growing ornamental plants as organic fertilizers, germination media and growth media. In ornamental plant growth, which has an economical value, the use of sewage sludge helps to decrease the high production costs and thus contributes to the economy of the country creating a new alternative field in removing the sewage sludge.

Keywords: Sewage sludge; reuse; ornamental plants; grassland.

1. INTRODUCTION

Although the domestic and industrial sewage sludge poses a serious threat for the future, it may be removed without damaging the environment with the developments in waste water purification sector; and the sludge is used in various forms to become useful for the environment. Especially the acceptance of these wastes in the soil-plant nutrient system as organic fertilizers ensure that they are recycled in the most economic and efficient method [1,2].

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The sewage sludge whose pathogens are eliminated and which doesn't contain heavy metals being given to the soil as organic fertilizer is accepted as an efficient and environment-friendly method [3,4].

Many factors in ornamental plant growing increase the production costs and makes the production uneconomic. Among these factors that increase the production costs are the fertilizers, germination and growing media. When considered in this context, the use of sewage sludge in ornamental plant growth emerge as an alternative in decreasing the costs of the growth media and fertilizer, which are important in this field. Positive results have been obtained in recent years in the use of composted industrial and urban wastes as germination media in ornamental plant growth. The sewage sludge being rich in organic materials, macro and micro nutrients make it possible to use it alone or in combination with various media as growth media in growing ornamental plants [5-7].

However, considering that the sewage sludge also has contaminating effects, it must be used with care in areas where ornamental plants are grown, and the regulations and the audits on this field must be applied and cared for with sensitivity. Because the possibility of sewage sludge carrying toxic organic compounds that are harmful for the environment, heavy metals, eggs of pathogen microorganisms and parasitic organisms as well as organic material and nutrient elements must not be ignored.

It has been reported by many researchers that the best method to make use of the nutrients contained in sewage sludge is its use in agricultural areas; however it is also reported that before the application, the heavy metal, salt, nitrogen and pathogen amounts must be determined. The amount that may be given to the agricultural areas must also be determined before use [8-10]. The sewage sludge which is non-biodegradable and which is collected in soil may be a risk for the environment in the long-term [1,11]. The use of waste sludge in seasonal flowers growing in gardens, green areas or in flower pots decrease the possibility of using the heavy metals and toxic organic compounds in the products that are nutrients from humans and animals [12].

According to the agricultural usage criteria, when the sewage sludge with high Cd, Zn, Cu and Ni concentrations is used in some seasonal plant species like *B. semperflorens*; *O. japonicus*; *L. chindense*var. *rubrum*; *D. morifolium*; *B. radican*; *V. macrocephalum*; *O. fragrans*; *C. camphora*, they show better development when compared with the control groups; and the highest Ni, Cu, As, Pb, Cd and Cr concentration was determined in the *D. morifolium* species; and it was reported is some studies that the Cu concentration in all plant species was higher than 20 mg/kg, which is the toxic limit for plants [13].

It has been stated that in *Bougainvillea* growing, in which the sewage sludge is used in various percentages (0%, 25%, 40%, 55% and 70%) with the purpose of preparing agriculture-friendly compost, especially the *peat medium* should be preferred [14]. In a study in which the effects of heavy metals in sewage sludge on the development of *Chlorophytum comosum, Calendula officinalis* L, *Petunia hyhrida* Vilm and *Viola tricolor* were investigated, it was determined that the Cu, Zn and Pb amounts were higher in *Chlorophytum comosum* in the body; and the Cd amount was higher in *Calendula officinalis* L; and in the roots it was determined that the *Chlorophytum comosum* absorbed Cu, Zn, Pband Cd; and that the *Chlorophytum comosum* had the best phytoremediation (*phyto-remediation*) value [15].

The effect of the toxic metals in sewage sludge on some shrubs or small trees and on many outdoor plants has been investigated in various studies. For example, it has been determined that heavy metals accumulate in the plant tissues of *Terminalia arjuna*, *Prosopis juliflora*, *Populus alba*, *Eucalyptus tereticornis* and *Dendrocalamus strictus*. In other words, these plants attract the heavy metals in the medium like a magnet, and purify the soil from heavy metals. It was determined that in *E. tereticornis* species, mostly Fe, Cu, Mn and Zn metals are accumulated and in *T. arjuna* species, mostly Cd and Ni metals are accumulated. As a result, it was observed that after 1 year of the study, the toxic metals were removed from the medium in various ratios (Cr % 70.22, Ni % 59.21, Cd % 58.4, Fe % 49.75, Mn % 30.95, Zn % 22.80, Cu % 20.46 and Pb % 14.05 [16].

Normal and enriched sewage sludge was applied to *Pinus halepensis* saplings (Cu, Ni and Zn), and it was observed that the enriched sewage sludge caused an increase in the heavy metal concentrations in the plant; however, it did not reach toxic level. It was also observed that in the other application, the Cu and Zn concentrations decreased in small levels in the saplings [17].

In the study on the potential of sewage sludge being used as growth medium for *Cupressus macrocarpa* 'Gold Crest' was investigated and it was observed that the sewage sludge in increasing dosages decreased the C/N rate, and made the soil reach to the desired levels in terms of physical and chemical properties. It was also reported that the best results in terms of plant growth performance were obtained from the mixtures prepared with 30% and 50% sewage sludge [18].

In another study , various dosages (0, 7.5, 14.5 kg dry weight/plant) of sewage sludge was applied to the saplings of *Pinus halepensis* and *Quercus ilex* in forest areas and it was determined that the growth ratio was positive in *P. halepensis* species with the highest sewage sludge dosage and negative in *Q. ilex* species [19].

In a study in which the use of the mixtures of *Pinus pinea*, *Cupressus arizonica* and *Cupressus sempervirens* being used as growth medium was investigated, it was reported that *C. arizonica* and *C. sempervirens* gave very good results in the growth medium which was formed with pine bark, coir and 30% sewage sludge [20].

A study conducted on forest areas that were burnt by applying sewage sludge made into compost and green wastes (0, 20 and 40 kg/m^2) to one-year-old *Quercus ilex*, *Pinus halepensis* and *Pinus pinea* saplings for three years, and it was determined that the development in *Q. ilex* and *P. Pinea* saplings in dry period increased in all saplings; and that there was no effect on *P. halepensis*. It was also determined that generally the diameter and the length of the body and plant nutrient elements (N, P, K) increased in all saplings [21].

Many studies have been conducted on the use of sewage sludge in outdoor ornamental plants as well as cut flowers growing. Sewage sludge in various amounts was applied to *Freesia* spp. plants grown in flower pots and 60 t/ha yield was obtained in the number of the flowers per plant, 180 t/ha yield was obtained in the number of the ruddles, 90 t/ha yield was obtained in the burl diameter, and 90 t/ha yield was obtained in the number of the offspring of the burls [10].

There have been many studies conducted on the use of sewage sludge during seed germination. Sewage sludge in 4 different dosages (0, 40, 80 and 120 t/ha) were applied to grass species in which *Lolium perenne* (40%), *Festuca rubra* var. *rubra* (30%), *Poa pratensis* (15%) and *Festuca rubra* var. *comutata* (15%) were used as mixtures, and it was observed that the sewage sludge increased the Zn, Ni, Cu, Cr and Pb content when compared with the control group, and this increase was observed mostly in the Pb, Zn and Cr content; and there was a decrease in Mn content [22]

In a study in which the effects of sewage sludge on growth, development and grass area quality of *Zoysia japonica* and *Poa annua* grass species was observed and was reported that the sewage sludge applied in various dosages (0, 15, 30, 60, 120 and 150 ton/ha) increased the heavy metal content in the soil; and it was determined that the Zn, Pb and Cu did not exceed the limit values; however, Cd exceeded the limit values [9].

Industrial waste sludge in various amounts was applied to *Canna indica* in flower pot and the effects of this application on plant growth and the transport of some heavy metals in the plants were investigated. As a result, it was reported that with the increase in the amount of the sludge in the soil, the metal concentration also increased in some parts of the plant; however, *C. indica* adapted itself well to the industrial waste sludge application, and this plant is therefore recommended for green remedy works (*phytoremediation*) [23].

There have been studies conducted on which plant species might decrease the heavy metals in sewage sludge and as well as on the effects of sewage sludge applied in various dosages on plant properties. In a study in which the effect of sewage sludge and fertilizing on the fertility of *Salix viminalis* in forest areas was investigated it was reported that the sewage sludge increased the weed development in the first year because of its excessive nutrient content, and encouraged the offshoot and increased the fertility. However, it was also reported that the heavy metal content was 4-8% more than the control group, and therefore exceeded the limit values [24].

In a to another study, the tree types like *Quercus acutissimave Liriodendron tulipifera* grown in waste storage areas by applying sewage sludge were examined in terms of the effects of the sewage sludge on the soil and plants, it was determined that the moisture, organic matter, N content and respiration properties of the soil increased, and it was reported that the use of sewage sludge to purify the soil in waste storage areas was an environmental-friendly method [25].

In another study which was conducted as flower pot experiment with sewage sludge and garden compost it was reported that the mixture increased the plant development in *Ipomea aquatica* species, and that the highest fresh weight was observed in the 4% garden compost and 2% sewage sludge mixture [26].

In growth media in which nutshell and sewage sludge were mixed in various rates, the annual seasonal ornamental plants *Primula vulgaris* and *Tagates patula var.* n*ana* were used in a study, and it was determined that with the increase of the sewage sludge in the mixture, the height of the plants also increased. It was also reported that the body diameter, canopy diameter and dry weight values of *Primula* increased in media which contained sewage sludge [5].

In a study in which the effects of the application of sewage sludge and mineral fertilizer on *Diplotaxis erucoides* species was investigated it was reported that in the plants which received sewage sludge compost, the blooming was delayed; however, the biomass increased, and the plant developed bigger root system, and also the number of the seeds increased [27].

2. CONCLUSION

In the light of all these data, it is clear that the use of the sewage sludge in growing ornamental plants as germination medium, growth medium, and organic fertilizer should be spread in a way that will not harm the environment in accordance with the regulations of each country and this will be of great use for countries both in terms of economy and ecology. The use of sewage sludge in agricultural areas as well as in growing ornamental plants will enlarge the usage area of the sewage sludge in agricultural production. In addition, the psychological negative situation that emerges due to the use of sewage sludge in plants that are consumed in food chain being not observed in its use in ornamental plant growth makes it advantageous.

The use of waste water sewage sludge for the purpose of growing various ornamental plants in dimensions that will not cause environmental problems is recommended with the opinion that it is one of the most proper methods for modern recycling concepts.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Nogueirol RC, deMelo EI, Bertoncini WJ, Alleoni LRF. Concentrations of Cu, Fe, Mn, and Zn in tropical soils amended with sewage sludge and composted sewage sludge. Environ Monit Assess. 2013; 185:2929-2938
2. Zhao S, Shang X, Duo L. Accumulation and spatial distribution of Cd, Cr and Pb in mulberry from municipal solid waste compost following application of EDTA and $(NH_4)_2SO_4$. Environ Sci Pollut Res. 2013; 20:967-975.
3. Curaqueo G, Schoebitz M, Borie F, Caravaca F, Roldán A. Inoculation with arbuscular mycorrhizal fungi and addition of composted olive-mill waste enhance plant establishment and soil properties in the regeneration of a heavy metal-polluted environment. Environ Sci.Pollut Res. 2014; 21:7403–7412.
4. Zafari A, Kianmehr MH. Factors affecting mechanical properties of biomass pellet from compost. Environ Technol. 2014; 35:478-486.
5. Dede OH, Ozdemir O, Dede G. Fındık zürufu ve arıtma çamurlarının tek yıllık süs bitkisi yetiştiriciliğinde kullanılması. II. Ulusal Arıtma Çamurları Sempozyumu, 04-06 Kasım; 2009. İzmir. (in Turkish)
6. Bozdogan E, Cetinkale G, Sogut Z. Atıksu arıtma çamurlarının yeniden kullanımları. Ulusal Katı Atık Yönetimi Kongresi –UKAY. 2009;334-342. (in Turkish)
7. Cetinkale, G ve Z. Sogut. *Cynodon dactylon* (L.) Pers. çim alanlarında kentsel su arıtım sistem çamurlarından yararlanabilme olanakları. C.Ü. Fen Bil. Ens. Fen ve Mühendislik Bilim. Dergisi. 2010;23(3):11-21. (in Turkish)
8. Ozyazici MA, Ozyazici G. Arıtma çamurunun toprağın bazı temel verimlilik parametreleri üzerine etkileri. Anadolu Tarım Bilim. Derg. 2012;27(2):101-109. (inTurkish)
9. Wang X, Chen T, Ge Y, Jia Y. Studies on land application of sewage sludge and its limiting factors. Journal of Hazardous Materials. 2008;160(2-3):554-558.
10. Unal M, Karaca A, Camci CS, Celik A. The effects of the drinking water plant sewage sludge on plant development of the *Freesia* spp. and on some soil properties. Selcuk Journal of Agriculture and Food Sciences. 2011;25(2):46-56. (in Turkish)

11. Bhattacharya T, Chakraborty S, Banerjee DK. Heavy metal uptake and its effect on macronutrients, chlorophyll, protein, and peroxidase activity of *Paspalum distichum* grown on sludge-dosed soils. Environ Monit Assess. 2010;169:15-26.
12. Silva JDC, Leal TTB, Araújo ASF, Araujo RM, Gomes RLF, Melo WJ, Singh RP. Effect of different tannery sludge compost amendment rates on growth, biomass accumulation and yield responses of *Capsicum* plants. Waste Manage. 2010;30:1976-1980.
13. Dai J, Chen L, Zhao J, Ma N. Characteristics of sewage sludge and distribution of heavy metal in plants with amendment of sewage sludge. Journal of Environmental Sciences. 2006;18(6):1094-1100.
14. Vecchietti L, Lucia B, Russo G, Rea E, Leone A. Environmental and agronomic evaluation of containerized substrates developed from sewage sludge compost for ornamental plant production. Acta Horticulturae. 2013;431-439.
15. Bai XY, Liu HH, Han BP, Su XL, Qin F. Experimental study on ornamental plants remediation of heavy metals in sewage sludge. Environmental Science & Technology China. 2010;33(10):39-44.
16. Shukla OP, Juwarkar AA, Singh SK, Khan S, Rai UN. Growth responses and metal accumulation capabilities of woody plants during the phytoremediation of tannery sludge. Waste Management. 2011;31:115-123.
17. Fuentes D, Disante BK, Valdecantos A, Cortina J, Ramo´N Vallejo V. Response of *Pinus halepensis* Mill. seedlings to biosolids enriched with Cu, Ni And Zn in three mediterranean forest soils. Environmental Pollution. 2007a;145:316-323.
18. Ozdemir S, Koseoglu G, Dede OH. Arıtma çamurlarının süs bitkisi toprağı hazırlanmasında kullanımı, Dokuz Eylül Üniversitesi, I. Ulusal Arıtma Çamurları Sempozyumu Bildiri Kitabı, İzmir, 25-26 Mart. 2005;557-564. (in Turkish)
19. Fuentes D, Valdecantos A, Cortina J,Vallejo VR. Seedling performance in sewage sludge-amended degraded mediterranean woodlands. Ecological Engineering. 2007b;31(4):281-291.
20. Hernández-Apaolaza L, Gascó AM, Gascó JM, Guerrero F. Reuse of waste materials as growing media for ornamental plants. Bioresource Technology. 2005;96(1):125-131.
21. Larchevêque M, Ballini C, Korboulewsky N, Montès N. The use of compost in afforestation of Mediterranean areas: effects on soil properties and young tree seedlings. Science of The Total Environment. 2006;369(1-3):220-230.
22. Kucukhemek M, Gur K, Berktay A. Evsel karakterli atık su arıtma çamurlarının çim bitkisi ağır metal (Mn, Zn, i Cu, Cr, Pb, Cd) içeriği üzerine etkisi. Selçuk Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi. 2006;21(3-4):1-12. (in Turkish).
23. Bose S, Jain A, Rai V, Ramanathan AL. Chemical fractionation and translocation of heavy metals in *Canna indica* grown on industrial waste amended soil. Journal of Hazardous Materials. 2008;160:187–193.
24. Lazdina D, Lazdins A, Karins Z, Kaposts V. Effect of sewage sludge fertilization in short-rotation willow plantations. Journal of Environmental Engineering and Landscape Management. 2007;15(2):105-111.
25. Song U, Lee EJ. Environmental and economical assessment of sewage sludge compost application on soil and plants in a landfill. Resources, Conservation and Recycling. 2010;54:1109-1116.
26. Stabnikova O, Goh WK, Ding HB, Tay JH, Wang JY. The use of sewage sludge and horticultural waste to develop artificial soil for plant cultivation in Singapore. Bioresource Technology. 2005;96(9):1073-1080.
27. Korboulewsky N, Bonin G, Massiani C. Biological and ecophysiological reactions of white wall rocket *(Diplotaxis erucoides)* grown on sewage sludge compost. Environmental Pollution. 2002;117:365-370.

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