Research Article

Effect of sewage polluted by heavy metal on domestic crops

Abstract

The application of sewage water (SW) to irrigate and feed agricultural crops in Mexico is widespread due to the problem of scarcity in the country, and in the world. Agricultural crops not eaten raw irrigated and fed with SW benefit and/or harm directly or indirectly by the chemical composition that in industrial cities that includes heavy metals of risk to human health. The objective of this work was to analyze the effect of sewage with heavy metals on the growth and yield of an agricultural soil of "El Canada" N.L. Mexico. Compared with plant growth and yield in a soil from Cadereyta, Nuevo León, Mexico in greenhouse irrigated with ground water and conventional chemical fertilization. For which the concentration of heavy metals of the SW in the plant and the soil was determined. The results show that the SW used in the irrigation of agricultural crops supported plant growth. With no evidence that heavy metals caused any negative effect on plant growth and yield, despite the length of SW use, it is believed that some of these crops have developed tolerance to heavy metals regarding the risk to be consume by humans and animals.

Keywords: soil, phytoremediation, oligodynamic effect, soil, plant nutrition

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Introduction

Sewage for irrigation and feed of agricultural crops adds to the soil due to its chemical-biological composition, organic and inorganic compounds that stimulate the heterotrophic activity of the soil microbial population[1–4] because they enrich it with: Al (aluminum), Ca (calcium), Mg (magnesium), Mn (manganese), Fe (iron), B (boron), Cu (copper), Mo (molybdenum), Sr (strontium), Ba (barium), Na (sodium), Cu (copper), Cd (cadmium, Fe (iron), Hg (mercury), Pb (lead) and Zn (zinc) and organic matter,[5–7] and even heavy metals which can translocate in the food chain and be toxic to life.[8,9]

In the soil, their low concentration makes them essential for microbial and plant growth,[10–12] the toxicity of the metal depends on the concentration and chemical state and on the physical-chemical properties of the soil[13] since the native microflora potentially methylates heavy metals and releases them as volatile compounds that contaminate the soil while there is evidence that the radical absorption of heavy metals by plants can cause them to have growth problems with lower yield as well as causing bioaccumulation in plant tissues to be a risk for human and/or animal consumption.[9,14] The objective of this work was: i) To analyze the effect of heavy metals on the growth and yield of plants grown in agricultural soil.

Material and methods

Soil collection: 80 samples were taken from February to December 2016 in plastic bags for the soil Microbiology Laboratory. They were dried at room temperature/24 h. They were screened with a 20 mesh/inch sieve and analyzes of their physicochemical properties were carried out: a) texture: Bouyoucos Hydrometer, b) moisture content and water retention capacity, c) pH: Potentiometer, water/soil ratio 2 :1, d) Salts: Electrical conductivity, e) Organic matter content.[15]

This research was carried out on the soil of the ejido "El Canada" of Escobedo, in the state of Nuevo León (N.L.), in northeastern Mexico. with an extension of 1500 hectares of which 90% is irrigated with SW since 1990. The soil of Cadereyta Jiménez, N.L. Mexico, irrigated with well water, this was used as an absolute control, for the comparison between soils.[8]

Evaluation of the effect of SW on plant development: In aluminum containers with 200 g of soil from the ejido "El Canada" and Cadereyta, N.L. Seeds of *Zea mays, Phaseolus vulgaris* and *Triticum aestivum*, were irrigated and feed with SW after sowing their dry weight and yield were determined.[1]

Heavy metal detection: Cu, Cd, Fe, Hg, Pb and Zn were quantified in SW, *T. aestivum*, in *Z. mays, S. vulgare* and agricultural soil of the ejido "El Canada" Escobedo, N.L., with a Carl Zeiss model FMD 4 atomic absorption spectrophotometer. The treatment of each sample was as follows: 5 ml of concentrated H_2NO_3/L of sample were added as a preliminary treatment: 500 ml of SW were deferred in 10 ml of concentrated HCl, the sample was concentrated to a volume of 10 ml, Subsequently, it was calibrated to 50 ml with bidistilled water and the metals were determined in the atomic absorption spectrometer.[16]

Soil and plants

The soil was air-dried for 24 h and sieved with a 20-mesh/inch sieve; the plants were washed and dried at 60ºC/48h, then ground; As a preliminary treatment, 100 g of soil and/or 10 g of plants were digested with 100 ml of a mixture of concentrated H_2NO_3 and H_2SO_4 and 62% perchloric acid. Each sample was concentrated to a volume of 10 ml and filtered with Whatman 41 paper. It was calibrated to 50 ml with bidistilled water and finally the heavy metals were determined with a Carl Zeiss model FMD 4 atomic absorption spectrophotometer.[9,17] The results were validated by ANOVA/Tukey HSD ($P<0.01$).

Results and discussion

Table 1 shows the physicochemical analysis of the soils of the ejido "El Canada" Escobedo, N.L. and Cadereyta Jiménez, N.L. México; the soils were rich in organic matter, with an alkaline pH, with a silt crumb texture and not saline; an increase in organic matter of 3.9% and salts of 1.3 mmhos was detected in the soil of the ejido "El Canada", while in the soil of Cadereyta (absolute control) it was 2.4% and 0.6 mmhos respectively, the remaining properties remained. Likewise, this suggests that the SW contributed salts and organic matter to the soil.[13,17] No statistical difference was found in the physicochemical properties of the soil, although they have changed due to the constant addition of SW for more than 40 years.[13,15,18]

Table 1 Physico chemical soil analysis from Nuevo León, State, México, for the assays

Soil[1]	pH	WRC[1]	Texture	moisture	Organic matter	Salinity mmhos
Ejido Canáda Escobedo N.L.	7.5*	65%	Migajón limoso	19%	3.90%	1.3
Cadereyta Jiménez NL	7.7	57%	Migajón limoso	20%	2.40%	0.6

[1]WRC, Water retention capacity; *Values represent the average of 10[1] replicates

Table 2 shows the increase in the dry weight of 20-day-old plants in soils, reaching the highest yield than in the soil of the ejido "El Canada", this suggests that SW provided nutrients to favor its productivity and it was even better than what was observed in the Cadereyta ejido where nitrogenous fertilizers are applied.[18,19] In the same table 2 shows that the dry weight of the plants irrigated with SW was not different than with groundwater, probably the SW contributed organic matter and mineral salts;[18] although they exerted a positive effect on plant yield, probably due to the time in which they were applied. When they were irrigated with groundwater was insufficient to cause an increase in its dry weight since due to the lack of mineral salts essential for plant growth.[17,20]

Table 2 Dry weight (g) of crops at soils fed with sewage and groundwater of Nuevo León State, México

Crop+	Ejido "el Canadá" / Escobedo (sewage) (g)	Cadereyta (groundwater) (g)
Phaseolus vulgaris	0.40[a]*	0.37[a]
Zea mays	0.30[a]	0.17[c]
Triticum aestivum	0.04[a]	0.03[a]
Sorghum vulgare	0.33[a]	0.18[c]

+20 days after sowing in greenhouse. The values represent the average of 20 plants, *same letters without statistical difference ANOVA/Tukey HDS (P<0.01)

Table 3 shows that SW influenced the yield of agricultural crops in soils of the "El Canada" ejido in comparison with the yield in soil of Cadereyta Jiménez, N.L., which was irrigated with groundwater where a higher yield due to the contribution of nitrogen, phosphorus and other minerals necessary for the growth and production of healthy plants. Besides that microbial heterotrophic activity is increase which enhance that basic minerals are improving mineral uptake by the root of plants sowing in the soil irrigated by SW.[14,20]

Table 3 Average of yield of crops irrigated and fed with sewage and ground wáter

Crop1	"el Canadá", Escobedo, N.L. México	Cadereyta, N.L., México
	(Ton/Ha (sewage)	(groundwater) Ton/Ha
Triticum aestivum	3.2[a]*	2.3[b]
Zea mays	3.0[a]	2.2[b]
Sorghum vulgare	3.8[a]	2.3[b]
Phaseolus vulgaris	0.6[a]	0.8[a]

[1]Represent average of 20 replicates, *same letters without statistical difference according to ANOVA/Tukey HDS (P<0.01).

Table 4 shows the average Cu concentration in the SW with 0.25 ppm, which increased 4.2 times more in the soil with 1.07 ppm, while in *T. aestivum, S. vulgare, Z. mays* it increased 2.5 times with 0.63 ppm. While Cd was detected in the SW at a concentration of 0.13 ppm in the soil, it was 0.20 ppm without being detected in *T. aestivum, S. vulgare, Z. mays*. In contrast, Fe was detected in the SW at a concentration of 27.0 ppm, in the soil it reached 140 ppm and in *T. aestivum, S. vulgare, Z. mays* with 9.8 ppm. In the case of Hg, it was detected in the soil at a concentration of 1.6 ppm, 9.4 ppm in the soil but not in *T. aestivum, S. vulgare, Z. mays*. Regarding Pb, it was found in the SW at a concentration of 4.2 ppm, in the soil it was detected at a concentration of 8.3 ppm and 0.4 ppm in *T. aestivum, S. vulgare, Z. mays*. While Zn in the SO concentration was 4.9 pm, in the soil it was 11.9 ppm and in *T. aestivum, S. vulgare, Z. mays* with 7.6 ppm. It was evidence that in no case the risk metals Cd, Hg and Pb were uptake by *T. aestivum, S. vulgare, Z. mays*. The response of agricultural crops indicates that these plants developed some intrinsic mechanisms to avoid the toxic effect of heavy metals on their growth[15,19] in such so that they are a risk for human or animal consumption, unlike *P. vulgaris* where no heavy metal was detected due to its biochemical way of dealing with heavy metals to avoid any uptake process.[19] In this sense, it should be investigated if there is the possibility that SW containing heavy metals can be applied to agricultural crops specifically when the metals uptake by root of plants based on the analysis, the concentration so far has no risk according to international regulation[21] that determine the possible cell damage based on the presence of heavy metals in plant food that consumed by humans and animals,[4] due to the problem of scarcity of fresh or groundwater in Mexico, and in the world for safe agricultural production.[7]

Table 4 Average concentration of heavy metals in sewage in soil and in *T. aestivum[1], S. vulgare[1], Z. mays[1]* from "Ejido Canada", Escobedo, N. L. State, México

Metal concentration (ppm)[1]	In sewage	In soil	In crop
Copper (Cu)	0.25[c]*	1.07[a]	0.63[b]
Cadmium (Cd)	0.13[b]	0.20[a]	0
Iron (Fe)	27.0[c]	140.4[a]	9.8[d]
Mercury (Hg)	1.6[d]	9.4[a]	0
Lead (Pb)	4.2[c]	8.3[a]	0.4[e]
Zinc (Zn)	4.9[d]	11.9[a]	7.6[c]

[1]Values represent the average of 20 plants, *Same letters without statistical difference according to ANOVA/Tukey HDS (P<0.01).

Conclusion

The results found suggests that the physical and chemical properties of the soil had a buffering effect on the activity of heavy metals coming from SW while the plants in the root system developed with the microbiota that colonized them tolerance to metals due to feed by SW, which indicates that it is possible to select them for this environmental condition regarding the research has to be done to avoid the risk for the consume for humans and animals when heavy metals concentration are relatively high due to type crops feed by SW.

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Conflict of interest

The authors declares there is no conflict of interest.

References

1. Arora M, Kiran B, Rani S, et al. Heavy metal accumulation in vegetables irrigated with water from different sources. *Food Chem*. 2008;111:811–815.
2. Al Omron AM, El-Maghraby SE, Nadeem MEA, et al. with the treated sewage effluent on some soil properties of Al-Hassa Governorate, Saudi Arabia. *J Saudi Soc Agric Sci.* 2012;11:15–18.
3. Bharose R, Lal BS, Singh KS, et al. Heavy metals pollution in soil--water-vegetation continuum irrigated with ground water and untreated sewage. *Bull Environ Sci Res.* 2013;2(1):1–8.
4. Alrawiq N, Khairiah J, Talib ML, et al. Accumulation and translocation of heavy metals in soil and paddy plant samples collected from rice fields irrigated with recycled and non recycled water in MADA Kedah, Malaysia. *Int J Chem Tech Res.* 2014;6(4):2347–2356.
5. Siebert S, Burke J, Faures JM, et al. Groundwater use for irrigation—A global inventory. *Hydrol Earth Syst Sci*. 2010;14:1863–1880.
6. Parveen T, Hussain A, Rao S. Growth and accumulation of heavy metals in turnip (*Brassica rapa*) irrigated with different concentrations of treated municipal waste water. *Hydrol Res*. 2015;46(1):60–71.
7. Zhang Y, Shen Y. Wastewater irrigation: Past, present, and future. Wiley Interdiscip. *Rev Water*. 2017;6:e1234.
8. Assadian NW, Esparza LC, Fenn LB, et al. Spatial variability of the heavy metals in irrigated alfalfa fields in the upper Rio Grande River basin. *Agricultural Water Management*. 2000;34:81–94.
9. Hussain A, Priyadarshi M, Dubey S. Experimental study on accumulation of heavy metals in vegetables irrigated with treated wastewater. *Appl Water Sci*. 2019;9:122–132.
10. Al-Jamal MS, Sammis TW, Mexal JG, et al. A growth-irrigation scheduling model for wastewater use in forest production. *Agricultural Water Management*. 2002;51:53–78.
11. Parveen T, Hussain A, Rao S. Growth and accumulation of heavy metals in turnip (*Brassica rapa*) irrigated with different concentrations of treated municipal waste water. *Hydrol Res*. 2015;46(1):60–71.
12. Cossio C, Perez-Mercado LF, Norrman J, et al. Impact of treatment plant management on human health and ecological risks from wastewater irrigation in developing countries—Case studies from Cochabamba, Bolivia. *Int J Environ Health Res*. 2019;2(29):1–19.
13. Chaoua S, Boussaa S, El Gharmali A, et al. Impact of irrigation with wastewater on accumulation of heavy metals in soil and crops in the region of Marrakech in Morocco. *J Saudi Soc Agric Sci*. 2019;18:429–436.
14. Hanjra MA, Blackwell J, Carr G, et al. Wastewater irrigation and environmental health: Implications for water governance and public policy. Int. J. Hyg. Environ. *Health*. 2012;215:255–269.
15. Ma S, Hu Y, Zeng Q, et al. Temporal changes of calcareous soil proprieties and their effects on cadmium uptake by wheat under wastewater irrigation for over 50 years. *Chemosphere*. 2021;263:127971.
16. Kiziloglu FM, Turan M, Sahin U, et al. Effects of untreated and treated wastewater irrigation on some chemical properties of cauliflower (*Brassica olerecea* L. var. botrytis) and red cabbage (*Brassica olerecea* L. var. rubra) grown on calcareous soil in Turkey. *Agric Water Manage*. 2008;95:716–724.
17. Mapanda F, Mangwayana EN, Nyamangara J, et al. The effect of long-term irrigation using wastewater on heavy metal contents of soils under vegetables in Harare, Zimbabwe. *Agric Ecosyst Environ*. 2005;107(2):151–165.
18. Chung BY, Song CH, Park BJ, et al. Heavy metals in brown rice (Oriza sativa L) and soil after long-term irrigation of wastewater discharged from domestic sewage treatment plants. *Pedosphere*. 2011;21(5):621–627.
19. Gupta N, Khan DK, Santra SC. An assessment of heavy metal contamination in vegetables grown in wastewater-irrigated areas of Titagarh, West Bengal, India. *Bull Environ Contam Toxicol*. 2008;80:115–118.
20. Sinha S, Singh S, Mallick S, Comparative growth response of two varieties of *Vigna radiata* L. (var. PDM 54 and var. NM 1) grown on different tannery sludge applications: effects of treated wastewater and ground water used for irrigation. *Environ Geochem Health*. 2008;30:407–422.
21. FAO/WHO. Joint FAO/WHO Food Standards Programme Codex Committee on Contaminants in Food. 2011. p. 64–89.

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