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Landfill leachates as an abiotic disease factor affecting solanaceous crops and olive trees

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ABSTRACT

Different landfills in Jenin district were selected in this research, and are considered the main garbage destination for the north part of the West bank. Due to their expected drastic effect on agriculture, the experiment was carried out to study the impact of such landfills on nearby olive orchards. The results showed that the landfills since their establishment caused drastic reduction of olive production from an average of 1500 kg/hectare in 2005 to 560 kg/hectare in 2009. Furthermore, olive production in the studied area stopped absolutely in 2011 due to complete olive orchard failure.

On the other hand, the effect of landfills was studied on vegetables under lab conditions. Therefore, different dilutions of the landfill leachate were used to irrigate tomato and pepper plants. The results showed that leachate caused plant stunting and reduction in leaf surface area when compared with control regardless of dilution used, but more pronounced in dilution zero. On the other hand, chlorophyll concentration was more in plant treated with zero dilution of leachate when compared with other treatments. Number of dropped leaves was more in plant treated with zero dilution of leachate when compared with other dilutions and control. The plants treated with zero dilution died before others treatments. **Conclusion:** leachate may have a drastic effect on nearby cultivated plant and could affect plant growth and lead to premature plant death.

Key word: Leachate, landfills, agriculture, Palestine.

INTRODUCTION

A landfill or rubbish dump is a place for the disposal of waste materials by burial. Worldwide, landfills are the oldest form of waste treatment and have been the most common methods of organized waste disposal [1].

Landfills may include internal waste disposal sites (where a producer of waste carries out their own waste disposal at the place of production) as well as sites used by many producers. Furthermore, many landfills are used for waste management practices, such as temporary storage, consolidation and transfer, or processing of waste material (sorting, treatment, or recycling) [2].

A large number of adverse impacts may occur from landfill operations. These impacts include: local environment pollution (such as pollution of groundwater and/or aquifers); production of potent gases as methane which is generated by decaying organic wastes. Such gas is explosive and harmful to humans and animals [3,9]; reproduction of disease vectors such as rats, mosquitoes and flies; nuisance problems; and injuries to wildlife and agro ecosystem by causing growth problems for vegetation growing on and adjacent to refuse landfills [4,5].

Furthermore, liquid chemicals, known as leachates, which drain or leach from landfills, may contaminate soil with their dissolved and suspended material [6]. Sometimes, soil remains contaminated with long after waste dumping has ceased. Such situation causes drastic effect on agriculture as vegetables and other edible plants grown in such soil can absorb such harmful chemicals and accumulate them in their tissues. Sometimes plants are unable to grow and live [7].

Ecologically, contamination of the soil affects the balance of any system depends on soil as a medium. Most plants are unable to adapt and live when the chemistry of the soil changes so radically in a short period of time. The fertility slowly diminishes, making land unsuitable for agriculture and any local vegetation to survive [8].

The current project aims to study the drastic effect on landfill leachates on agriculture and provide guidelines that may additionally help applicants, developers, consultants and the general public identify important design considerations to avoid adverse impacts on agricultural resources and land use. Landfill leachate is liquid that moves through or drains from a landfill. This liquid may either exist already in the landfill, or it may be created after rainwater mixes with the chemical waste

Therefore, the project studies the impact of landfill leachate that coming out of the landfills in Palestine on some vegetables and olive trees. The effect on olive trees was studied *In Vivo* on olive orchards grown near landfills. The other part which studies its effect on vegetables was done under lab condition. The landfills which were selected for the current study are considered the major landfill in northern part of the West Bank. Beside their horrible smell; their environmental impact especially on surrounding vegetation is not yet investigated (Fig 1).

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Fig 1: Landfill leachates flowing in agricultural areas

MATERIALS AND METHODS

3.1 Landfill of study

Landfills located in Jenin governorate were selected around the Jenin city. These landfills are considered the major garbage destination for the north part of the West Bank [11].

3.2 Leachate collection

Leachate was collected manually from liquids coming of the landfill. The liquid was filled in bottles with tightly caps and transferred to the lab for further experimentation (Fig 2).

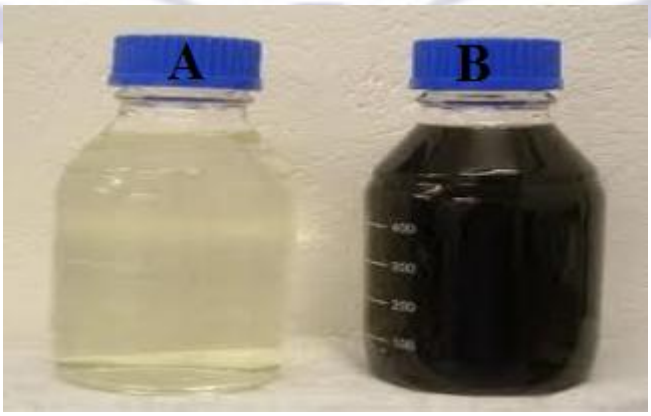

Fig 2: Visual comparison between leachate and water. A: water, B: leachate

Effect of landfill leachate on pepper and tomato

Twenty plants of Bell pepper and tomato each were planted in small pots. The pots were divided into five groups with five replicates. Four groups were irrigated separately with different dilution of landfill leachate including 0x, 2x, 3x and 4x (the number represents the volume of water and x represents the volume of leachate. The fifth group was irrigated with tap water to represent the control treatment of the experiment. The experiment was laid out according to the Completely Randomized Design (CRD) [16]. Ten ml of liquid was added to plants every 2 days during the first week and then the amount was adjusted according to plant growth. The plants were incubated under lab condition for further analysis of chlorophyll content and vegetative growth.

3.3 Chlorophyll analysis

The amount of Chlorophyll in the leave was determined according to Beer's-Lambert law (A = εbC), where "A" is the absorbance, "ε" is the extinction coefficient, "b" is the path length and "C" is the concentration, described by [12]. Leaves were extracted first with 80% acetone aqueous solution. Then the extracts were incubated at ¯10 degree Celsius. Total chlorophyll was measured at 646, 663 and 750 nm wavelengths using a Perkin-Elmer's spectrophotometer [10].

3.4 Vegetative growth measurement

Leaf surface area was measured using the tracing technique according to Ferris *et. al.* 2001 [13]. Paper replica of the surface was compared with the standard data using the following equation:

Leaf area (mm^2) = weight of leaf tracing (g) x conversion factor ($mm^2\ gm^{-1}$).

In addition, plant length was measured using a ruler and the number of dropped leaves was recorded daily as well.

3.5 Effect of leachate on olive production

The effect of leachate on olive tree in term of yield was recorded for the previous four years of olive orchards. Data was collected by interviewing and asking expert farmers and/or farm workers.

3.6 Statistical analysis

Analysis of the data was performed using the Two-Sample Test of Proportion (TSTP). The results were analyzed by comparing the Computed Z value with its critical one of 1.65 at the level of significance when α=0.05 [14,15].

$$H_o : p_1 - p_2 = 0$$

$$Z = \frac{(\hat{p}_1 - \hat{p}_2) - 0}{\sqrt{\hat{p}_C(1-\hat{p}_C)\left(\frac{1}{n_1} - \frac{1}{n_2}\right)}}$$

$$\hat{p}_C = \frac{Y_1 + Y_2}{n_1 - n_2}$$

Where,

Y_1 and Y_2 = Number of affected population type I and II respectively.

n_1 and n_2 = Sample size of population I and II respectively.

$\hat{p}_C$ = Combined proportion.

$\hat{p}_1 = \frac{y_1}{n_1}$ and $\hat{p}_2 = \frac{y_2}{n_2}$ = Sample proportion of population type I and II respectively.

RESULTS

4.1 Effect of landfill leachate on pepper and tomato

Irrigating pepper and tomato plants with leachates caused drastic effect on vegetative growth. The plants (tomato and pepper) became stunted in growth with obviously decreased leaf surface area when compared with control regardless of dilution used, but the highest drastic effect was obtained when higher concentrations of leachate were used.

The number of dropped leaves was much more in plant treated with absolute leachate when compared with the diluted ones and the control. Statistical analysis revealed significant differences between the control treatments irrigated with

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water and most treatments irrigated with leachate. Plants treated with absolute leachate died first before others plants in the other treatments (Table 1) (Fig 3)

Table 1: Average number of dropped leaves during the first 3 and 6 weeks

Weeks after treatment	Treatment code	Leachate concentration	Bell Pepper	Tomato
3	a	0x	4 ef	3 (ef)
	b	2x	3 ef	3 (ef)
	c	3x	3 f	2 (f)
	d	4x	2 f	1 (f)
	e	Control	0 abfghi	0 (abfghi)
6	f	0x	Plant died abcdeghij	Plant died (abcdeghij)
	g	2x	7 efj	6 (fj)
	h	3x	6 ef	5 (f)
	i	4x	4 ef	3 (f)
	j	Control	2 fg	1 (fg)

Letters beside treatment represent treatments with significant difference

Leachate concentration	Bell Pepper	Tomato
0x		
2x		

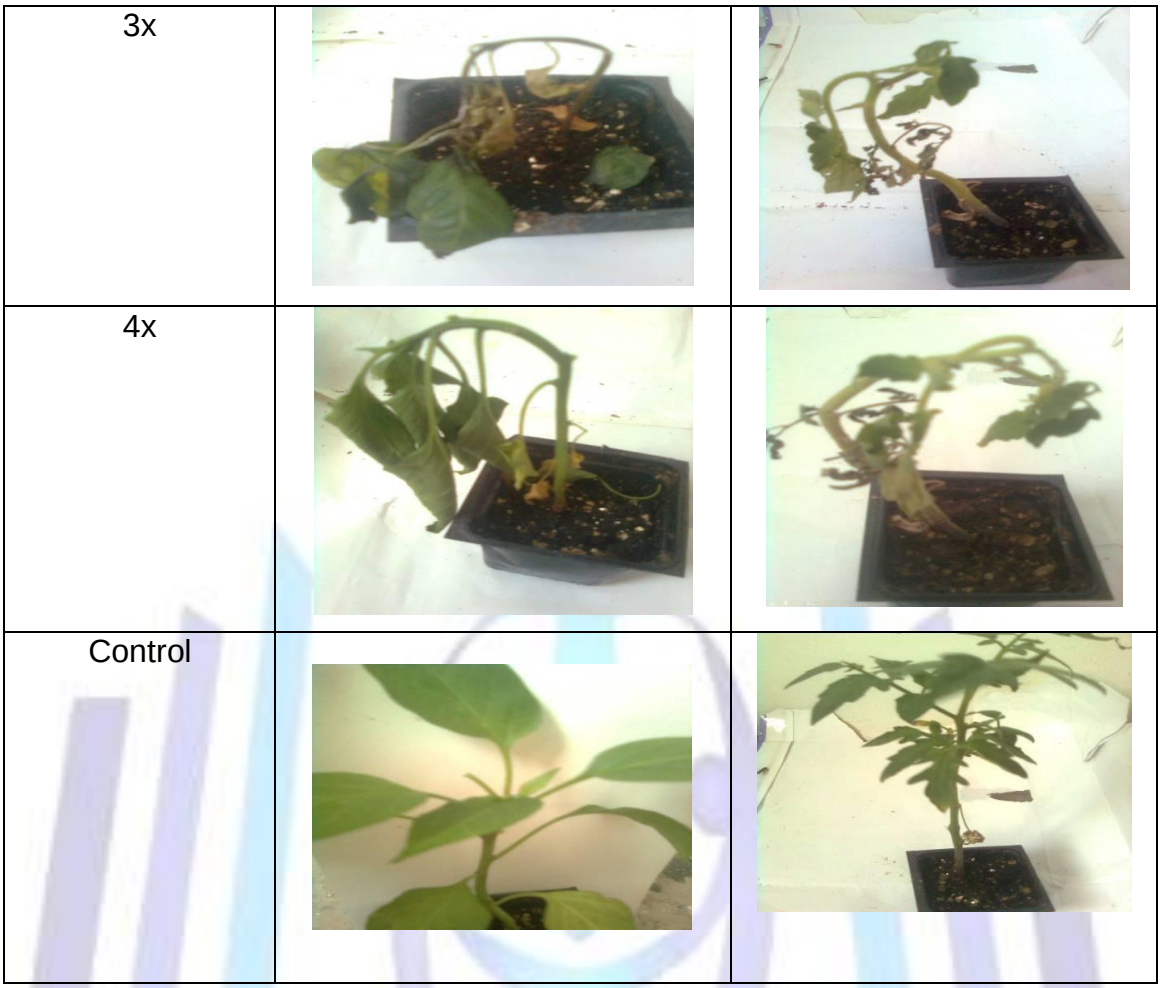

Fig 3: Effect of leaches on vegetative growth of pepper and tomato.

On the other hand, chlorophyll content was more in plant treated with absolute leachate compared with other treatments. The control treatment showed the least amount of chlorophyll content (Table 2).

Table 2: chlorophyll content (mg/ml) of the plants treated with leachate

Leachate concentration	Chlorophyll (a)	Chlorophyll (b)
0x	4.150	6.207
2x	3.363	4.970
3x	2.895	4.260
4x	2.273	3.209
Control	1.507	1.980

4.2 Effect of leachate on olive production:

The results obtained from olive farmers showed that leachate has drastic effect on olive production. From 2005 to 2009, the amount of olive production went down from an average of 1500 to 560 Kg/hectare for the lands 50 meters far from the landfill. Two years later, the net production went to nil. Furthermore, the adjacent fields exposed to direct leachate flow were destroyed. Statistical analysis emphasized such results (Table 3) (Fig 4).

Table 3: Effect of leachates on olive production

Year	Yield/ hectare (kg)
2005	1500 a
2009	560 b
2011	0 c

Similar letters represent no significant difference

Fig 4: Growth decline symptoms of olive trees grown near the landfills

DISCUSSION

The impact of landfill leachate that coming out of landfills on some vegetable plants as well as olive trees grown nearby the dump is one of the major problems facing agriculture in Palestine. Such material could affect plant growth of vegetables and leads to plant death one month after exposure to enough dose of leachate. Similarly, olive trees were affected also with leachate to the extent that the trees lose their vigor and become less productive. In severe cases, some of them may die.

The effect of leachate on the studied plants may be attributed to the toxic and hazardous chemical compounds coming off the chemical reactions that happen in leachate. The typical composition of landfill leachate is summarized in (Table 4) as reported by Tchobanoglous and Kreith [23]. Therefore, water resources of plants become polluted when the leachate from the landfill enters surface water or ground water resources. Also, the decomposition of carbonaceous material produces some additional water, and other materials including CH4, CO2 and a mixture of organic acids, aldehydes, alcohols and simple sugars, which dissolve in the leachate cocktail. The precipitation percolates through the waste and takes in dissolved and suspended components from the biodegrading waste, through physical and chemical reactions [17].

Table 4: Typical data on the composition of leachate in landfills

Constituent	Value, mg/l		
	New landfill		Mature landfill “greater than 10 years”
	“ less than 2 years” Rang	Typical	
BOD5	2,000-30,000	10,000	100-200
COD	3,000-60,000	18,000	100-500
TSS	200-2,000	500	100-400
Nitrate	5-40	25	10-10

Phosphorous	4-80	20	4-8
Alkalinity	1,000-10,000	3,000	200-1,000
pH	4.5-7.5	6	6.5-7.5
Total hardness	300-10,000	3,500	200-500
Calcium	200-3,000	1,000	100-400
Magnesium	50-1,500	250	50-200
Potassium	200-1,000	300	50-400
Sodium	200-2,500	500	100-200
Chloride	200-3,000	500	100-400
Sulfate	50-1,000	300	20-50
Total iron	50-1,200	60	20-200

Results showed that chlorophyll content was much more in plant treated with higher concentration of leachate compared with the other treatments. Such situation may be attributed to the composition of leachate which has very high ammoniacal nitrogen concentration [18]. Usually leachate from old landfills is rich in ammonia nitrogen due to the hydrolysis and fermentation of the nitrogenous fractions of the biodegradable wastes [19,22]. The research works reported that leachates contain much more organic pollutants than commonly found in any other organic effluent.

On the other hand, the high concentration of organic contaminant and much higher ammoniacal nitrogen of leachate may be responsible for agricultural and environmental problems as well as the loss of vegetation from polluted areas. Furthermore, excessive foliar nitrogen may affect the nutrient balance and increase plant sensitivity to harsh conditions as frost and drought, as well as the biotic factors including pests and pathogens [20]. In general, juvenile, fast-growing and well-nourished plants are more likely to be attacked by pests. A high content of amino acids in the plants may result in a more severe attack by sucking parasites [21].

CONCLUSIONS

Actually the production of domestic waste is increasing so much that landfill leachate has become a serious problem in Palestine in terms of the drastic effect on human health, environment and hazard to the agro ecosystem.

The outcomes of leachate irrigation trial have shown drastic effect on plants and phytotoxicity. Other research works have emphasized the importance of high concentration of ammonical-nitrogen of leachate which could be regarded as an alternative nitrogen source for plants [22,24,25,26]. Such controversial results may be attributed to variations in the composition complexity of landfill leachate, complexity in determining the phytotoxicity of the test individual and variation in the dilution factor and irrigation schedule. Therefore, a further research work is needed to study such issue and to concentrate on choosing the correct leachate dilution level is essential to safeguard the plants from toxicity damages and ensure healthy plant growth. Expanding trials to irrigate several types of agricultural crops including fruits trees is an indispensable step in the research to determine that plant types that can tolerate leachate

REFERENCES

[1] Chiemchaisri, W., Chiemchaisri, C., Odsang, U., Luknanulak, N., Tudsr, S., 2005. Effect of Leachate Irrigation on Landfill Vegetation and Cover Soil Quantities, Asian Journal on Energy and Environment, 6(02)116-124.

[2] Vesilind, P., Worrell, W., 2012. Solid Waste Engineering, 2nd Edition, Cengage Learning, Stamford, USA.

[3] Henry, J., Heinke, G., 1996. Environmental Science and Engineering, 2nd Edition, Prentice Hall.

[4] Young, A., 1992. DoE Report CWM039A+B/92, Washington State Department of Ecology, Solid Waste Landfill Design Manual.

[5] Hickman, Jr. L., Eldredge, R., 2005. "Part 3: The Sanitary Landfill", *A Brief History of Solid Waste Management in the US During the Last 50 Years*, http://www.forester.net/msw_0001_history.html. Retrieved August 29, 2005.

[6] Wong, M. H., 1988. Soil and plant characteristics of landfill sites near Merseyside, England, Environmental Management, Volume12,Issue4, pp 491-499.

[7] Jiansheng, L., Jianhua, Z., Chan, G., Minghong, W., 1999. Effect of Landfill Leachate Irrigation on the Growth of Subtropical Trees During Dry Season. Chinese Journal of Applied and Environmental Biology, Volume 5, Issue 03.

[8] Ward Andy D., Trimble Stanley W., 2004. Environmental Hydrology, 2nd Edition, Lewis Publisher, pp 369-372.

[9] Kjeldsen, P., Barlaz, M., Rooker, A., Baun, A., Ledin, A., Christensen, T., 2002. Present and Long-Term Composition of MSW Landfill Leachate: A Review. Critical Reviews in Environmental Science and Technology, 32(4):297-336.

[10] Lichtenthaler, H.K., Wellburn, A.R., 1983. Determinations of total carotenoids and chlorophylls a and *b* of leaf extracts in different solvents, Biochemical Society Transactions 11(5): 591 - 592.

[11] Al Sa'di, Mohammad, 2009. Reuse-Recycling Options for Municipal Solid Waste in Zahrat Al-Finjan Landfill. An-Najah National University, Faculty of Graduate Studies p. 2-3

[12] Mohr, H., Schopfer, P,. 1995. Plant Physiology. Springer-Verlag Berlin Heidelberg. P 225-243

[13] Ferris, R., Sabatti, M., Miglietta, F., Mills, R., Tylor G., 2001. Leaf area is stimulated in Populous by free air CO2 enrichment (POPFACE), through increased cell expansion and production. Plant, Cell and Environment 24 p 305-31

[14] Lind, D., Marchal, W., Wathen, S., 2005. Statistical Techniques in Business & Economics, Twelfth Edition, McGraw-Hill Irwin, New York, pp. 262-263.

[15] Montgomery, D., 2008. Design Analysis of Experiments, 7th Edition, John Wiley & Sons, pp. 60-98.

[16] Ott, L., 1984. An introduction to statistical methods and data analysis, Duxbury Press, Boston, pp. 667-683.

[17] Tyagi, S., 2013. Recent Advances in Bioenergy Research, Sardar Swaran Singh National Institute of Renewable Energy, Kapurthala. 339-341

[18] Clabaugh, M., 2001. Nitrification of Landfill Leachate by Biofilm Colums (M.Sc. Thesia), Blacksburg, Virginia 12-30

[19] Onay, T., Pohland, F.,1998. In Situ Nitrogen Management in Controlled Bioreactor Landfills. Wat. Res. Vol 32, No. 5. pp. 1383-1392.

[20] Dueck, T., Dorèl ,F., Horst, R., 1991. Eerden. Effects of ammonia, ammonium sulphate and sulphur dioxide on the forest sensitivity of Scots pine (Pinus sylvestris). Water Air Soil Pollut 54: pp. 35-49

[21] Marschner. H., 1995. Mineral Nutrition of Higher Plants, 2nd edition, London: Academic Press.

[22] Cheng, C., Tsang, C., Wong, R., Chu, L., 2011. Is Landfill Leachate a Potential Source of Nitrogen for Plant Growth? International Conference on Environment and Industrial Innovation, IPCBEE vol.12 (2011) © (2011) IACSIT Press, Singapore

[23] Tchobanoglous, G., Kreith, F., 2002. Handbook of Solid Waste Management, 2nd Edition. The McGraw-Hill Companies P. 14.34-14.35

[24] Maurice, C., Ettala, M., Lagerkvist, A., 1998. Effects of leachate irrigation on landfill vegetation and subsequent methane emissions. *Water Air Soil Pollut*. 113: pp. 203-216.

[25] Chan, Y., Wong, M., Whitton, B., 1999. Effects of landfill leachate on growth and nitrogen fixation of two leguminous trees (*Acacia confusa* and *Leucaena leucocephala*). *Water Air Soil Pollut*.111: 29-40.

[26] Stephens, W., Tyrrel, S., Tiberghien, J., 2000. Irrigation short rotation coppice with landfill leachate: constraints to productivity due to chloride. *Bioresource Technol*. 75: 227-229.