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Comparison of Seed Germination Efficiency of Maize Crop with Different Concentrations of Compost Leachate

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Abstract

Composting is the most economical and safest method to treat the organic fractions of waste. The liquid by-product of the compost is known as compost leachate, composed of essential plant nutrients and trace elements including nitrogen (N), carbon source (C) potassium (K), and phosphorus (P). It has the potential to replace the commercial fertilizers to stimulate plant growth. High concentration of compost leachate may result in a delay in seed growth and may damage the plats by phototoxicity.On day 1 about 68±1.2 seeds and on day 7 almost 97±0.5seeds were germinated in 3% leachate sample in each petri dish. The results showed that the higher concentration of compost leachate resulted in decrease in seed germination, as the seed treated with 25% leachate showed the growth about 35±1.2 on first day and 7th day germination index was around 46±0.5.Maximum seed germination and growth was observed in 3% leachate sample and lowest was observed in 25% leachate sample. On the other hand by increasing concentration of fertilizers from 3% to 25% resulted in increased seed germination on 1st day by 30±1.1-66±1.2 and until last day (7th day) by 66±1.2-75±0.5.This study was planned to check the potential of compost leachate compared with chemical fertilizer. According to the obtainedresults leachate has better fertilizing quality than fertilizer and its use as a liquid fertilizer is an environmentally sound and economically viable option.

Keywords: Leachate, Compost, Maize, Germination index

Introduction

The human population is growing rapidly due to which the need for food is also increasing. To enhance the production of food in modern agriculture, the use of agricultural products such as fertilizers, herbicides and insecticideshas become a core part and will continue in the future (Azizullah, et al. 2011). Most farmers have a wrong belief that application ofmaximum fertilizer will lead to higher yield production but this results in the contamination of natural

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resources (Ameen, 2020). Most of the fertilizershave a very slow rate degradation which magnifies their pollution capacity. Many chemical fertilizers contain substances that are toxic and lethalin the form of heavy metals, inorganic acids and organic pollutants (Li and Wu, 2008). There are sufficient pieces of evidence of the deadly effects of long duration application of thetoxic chemicals on aquatic and forest ecosystems worldwide (Howarth et al. 2002).In recent years, the main area of study was to investigate the effect of various organic waste on plant growth, on a low input and eco-friendly basis(Suthar 2007).The liquid by-product of the compost is known as compost leachate, composed of essential plant nutrients and trace elements including nitrogen (N), carbon source (C) potassium (K), and phosphorus (P) (Awais *et al.*,2020)). Humic acid is a part of this leachate can play a role in plant growth, compost leachate can increase plant growth, but the controlled availability of the micronutrient and macronutrient is recommended (Sanadia et al. 2019). while on the other hand high concentration of compost leachate may result in a delay in seed growth and may damage the plats by phototoxicity (Hashemi and Khodabakhshi 2016). Fresh compost leachate contains phytotoxic compounds, such as organic low molecular weight compounds, Ammonia, and high salt content compounds (Chatterjee et al. 2013).

Leachate is a source of dissolved organic matter, heavy metals, organic compounds, and inorganic macro components(Kjeldsen et al. 2002). Leachate can also contaminate the ecosystem, groundwater, and soil. So, it needs further treatment to meet the standards before discharge. In low concentration leachate is a source of nutrients for seed germination and plant growth. We can use leachate as chemical fertilizer with no further treatment. But various reports showed that leachate is the source of various inorganic and organic chemicals. The high amount of these chemicals in leachate is responsible for inhibiting plant growth including seed growth and seed germination(Shukla and Pandey 1991). Many studies reported the effect of wastewater and industrial pollutants in leachate on seed growth and seed germination (Shukla and Pandey 1991)(Vashisth and Nagarajan 2008). Agricultural production and plant growth depend on seed germination and seed growth, so the protection of plants from a higher concentration of these contaminants is necessary. The presence of heavy metal in leachate is also reported and their entry into the food chain may risk human health and may lead to the accumulation in soil and plant (Mishra et al. 2018).

Its utilization asa plant nutrient source would decrease the consumption of symthetic commercial fertilizesr for which a large amount and production cost is required. Chemical and synthetic fertilizer production is also the cause of massive greenhouse gas (GHG) emissions (Ha & Fike, 2015). Leachate being a waste product has no direct affiliated production costs, energy consumption, and GHG emission. The utilization of leachate in agriculture would also reduce the waste treatment plant's cost which is needed for the removal of excessive substances such as nitrogen and phosphorous (Romero, 2013).

Although in Pakistan open dumping is still a common practice. Due to the conventional solid waste collection and dumping system, Pakistan is generally facing rapid degradation of environmental conditions but in Lahore government is working on the proper management, treatment, and disposal of waste (Ali, 2014). Lahore is one of the major cities of Pakistan having a population of 8.7 million with an average growth rate of 3.5% per year (Punjab

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Development Statistics 2013). The waste generation rate is increasing rapidly due to increasing population, economic activities, and changes in consumption patterns. According to Butt and Iqbal (2007) in Lahore,the MSW generation rate is 5700 tons per day (0.65 Kg/c/day).

Now in Lahore, Lahore Waste Management Company (LWMC) is responsible for the collection, transportation, treatment, and disposal of municipal solid waste. Through the legal instrument of Services and Assets Management Agreement (SAMA) City District Government Lahore (CDGL) has assigned this duty to LWMC (LWMC 2013: Sezer, 2012). LWMC is making compost from a fraction of the MSW through Aerobic windrow composting. A project of the landfill site is in its construction phase at Lakhodair. So, it seems in near future there will be more composting and dumping sites in Pakistan

Material and Methods

Lahore Compost Company was selected as the basic site for the collection of municipal solid waste compost leachate.Samples of municipal solid waste compost leachate were collected from the leachate collection tank of Lahore Compost Company. They were stored in 1-liter airtight labeled polyethylene bottles rinsed out with the sample before the collection. After these samples were collected and transported to the laboratory in 1-liter airtight labeled polyethylene bottles, it was preserved at 4°C for further analysis.

Lahore Compost Company under an agreement with the City District Government Lahore (CDGL) at Mahmood Booti had set up the first composting plant. The rationale for selecting this site was that it was the only certified company in Lahore which is converting a portion of Lahore's waste organic matter into compost (organic fertilizer) through aerobic windrow composting. It is located in the north of Bund Road and along with the Mahmood Booti Landfill site Lahore (LWMC, 2013). This project was started in 2008 with an operational lifetime of 25 years. The objective of this project is to reduce the environmental degradation of the soil by replenishing organic content in the soil. The use of its leachate as a source of essential plant nutrients and also a source of micronutrient and macronutrient (Sanadia et al. 2019)will not only increase the effectiveness of this project but also make the composting process more cost-effective and environmentally friendly. Before the research, the site was visited to check the leachate collection system of Lahore Compost Company. The composting pad was adequately concreted and connected to drains to ensure that there is no seepage of effluent (leachate) into the ground. There was a proper system present for the collection of leachate. Leachate was collected and stored in a leachate tank.

Seed Collection:

Maize seed (*Zea mays L.*) was collected from Punjab seed corporation department Lahore.In thelaboratory, healthy seeds were screened out and stored in plastic zipper bags for use in the experiment.

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Heavy metal analysis:

The sample of compost leachate and commercial fertilizer were evaluated for the amount of heavy metals. For heavy metal analysis samples of leachate were treated with acid, 1.5 ml of nitric acid concentrated was added to avoid any growth of algae and other microbes. Fertilizer and leachate sample was digested as follows: 4.5g fertilizer dissolved in 10ml concentrated HCl and boiled at hot plate for approximately 35min in 150mL flask. 18mL of 0.24M HCl was added after gently cooling the solution. After filtration the volume was raised to 140ml with 0.1M HCl solution.

Statistical Analysis:

Data were processed in Microsoft Excel and analyzed in Statistical Package for Social Science (SPSS, version 2). The descriptive analysis was done to express the germination index of maize seeds by using composting leachate and Commercial fertilizer.

Results and Discussions

There are many factors which contribute to the yield of the crop one of them is seed germination (Buriro et al., 2011). Seed germination is a sensitive stage of plant's life. It is affected by the variations in internal conditions and environmental parameters (Li et al., 2005). Seed germination and vigorous seedlings are important characteristics for any crop which could provide advantages for its establishment. For the achievement of better growth and high yield of crop rapid and steady field emergence is necessary (Anaya &Fghire, 2015). In this study potential of Municipal Solid Waste (MSW) compost leachate as liquid fertilizer is checked by noticing its effect on maize seed germination and comparing it with a commercial chemical fertilizer.

Maize seeds have advantage of easy handling and rapid growth and are also resistant to some factors such as salinity, that's why they were used to for germination test to observe the effects (Nahum et al., 2005). By comparing with control results indicated significant difference between leachate and fertilizer. Maximum seedling length was observed in 3% leachate sample and lowest was observed in 25% leachate sample.Both leachate and fertilizer had affected the growth of maize. Results indicated that on lower concentrations leachate promoted the seed germination and seedling growth but on higher concentrations it resulted in reduced seed germination rate and seedling growth.Whereas in case of maize leachate treatments with 3% concentration produced positive effects on seed germination and seedling length as compared to control.

The results of data collected regarding the Maize seed germination in different leachate samples. According to the data on day 1 about 68±1.2 seeds and on day 7 almost 97±0.5seeds were germinated in 3% leachate sample in each petri dish. In 25% leachate sample germinated seeds were noticed on 1st day 35±1.2 and until last day (7th day) 42±1.2. Results showed that in the beginning there exist direct relation between increasing leachate concentration and seed germination from 3% to 25% samples. The results proved the hypothesis that due to the presence of essential plant nutrients such as nitrogen, carbon,

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potassium, phosphorous and other trace elements like zinc, calcium, boron, magnesium etc leachate could be utilized as liquid fertilizer (Quaik et al., 2012; Dimitriou, 2006). The analysis of data represented that increasing concentration of leachate has resulted in delayed germination of seeds (10%, 15% & 25%). Results also evidenced on high leachate concentration seed germination was inhibited, which indicates that dosage should be adjusted according to the crop and culture requirements (Cáceres, 2015). While on the other hand on 1st day about30±1.1seeds and on day 7 almost 41±0.5seeds were germinated in 3%commercial fertilizer in each petri dish. In 25%commercial fertilizer sample germinated seeds were noticed on 1st day around 66±1.2 and until last day (7th day) almost75±0.5. This data indicates that by increasing concentration of fertilizers resulted in increased seed germination (Table 1 and 2)

Table 1: Germination index of maize seeds by using compost leachate

Quantity	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
3%	68±1.2	80±0.5	93±0.5	96±0.5	96±0.5	97±0.5	97±0.5
10%	34±1.0	56±0.5	81±0.6	81±0.5	81±0.5	81±0.5	81±0.5
15%	35±1.0	44±0.5	52±0.53	80±0.5	80±0.5	80±0.5	81±0.5
25%	35±1.2	39±2.5	40±0.5	41±0.7	43±0.7	45±0.5	46±0.5

Table 2: Germination index of maize seeds by using Commercial fertilizer

Quantity	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
3%	30±1.1	34±0.5	33±0.5	38±0.5	39±0.5	41±0.5	42±0.5
10%	39±1.0	40±0.5	43±0.6	46±0.5	47±0.5	49±0.5	51±0.5
15%	40±1.0	44±0.5	45±0.53	49±0.5	51±0.5	53±0.5	55±0.5
25%	66±1.2	69±2.1	70±0.5	70±0.5	72±0.7	73±0.5	75±0.5

Results showed that on low concentration or in more dilution leachate has promoted the growth because of the presence of heavy metals (Table 3)

Table 3: Heavy metal analysis of leachate and commercial fertilizer

Metals	**Leachate**	**Fertilizer**	**FEPA Standards**	**NEQs for Effluents**
Zn (ppm)	0.53	31.10	-	1.0
Cu (ppm)	0.48	1.9	0.5	5.0
Cr (ppm)	1.19	12.95	0.2	1.0

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Ni (ppm)	0.57	4.7	0.01	1.0

This might be due to dilution of leachate which resulted in the dilution of toxic substances too and thus reduced their adverse effects. Compost leachate and fertilizer heavy metal analysis (Ni, Cr, Zn and Cu) is shown in table 3. It was observed in comparison of fertilizer with leachate that high amount of four heavy metals were found in commercial fertilizer as compared with standards set. Many synthetic fertilizers contain toxic substances and heavy metals. Results in this study wasn't surprising considering the fact that heavy metal content of commercial fertilizer is highly variable, mainly depends on the fertilizer source and its production process than leachate. The dilution of commercial fertilizer is required 2 folds more than leachate to avoid any toxicity in crops during growth. This dilution will also result in heavy metal quantity dilution. (Romero, 2013).Dilution had lowered the negative impacts which were produced due to leachate irrigation (Zhou & Wang, 2010). The results proved the hypothesis that due to the presence of essential plant nutrients such as nitrogen, carbon, potassium, phosphorous and other trace elements like zinc, calcium, boron, magnesium etc leachate could be utilized as liquid fertilizer (Miceli, et al. 2008; Dimitriou, 2006). On higher concentration 5% and above it negatively affected the growth of the crops. Dimitriou (2006) described that when short-rotation willow (Salixsp.) coppice, a crop grown commercially for energy purposes, when irrigated with higher concentrations of leachate had resulted in reduced relative growth rates. Zhou (2010) also had described that as increased concentration of leachate resulted in wilted growth of plant. Survival of Impatient became impossible because the plants were withered either partly or completely when irrigated with undiluted and untreated leachate. This was mainly due to the high levels of organic compounds, heavy metals and low pH value. Quaik et al. (2012) had documented that on higher concentration leachate might cause burning of leaf's surface. Dilution of leachate was strongly recommended by Quaik at al. when vermicompost leachate would be utilized as foliar sprays.

Conclusion

According to the obtained results, leachate reuse as a liquid fertilizer is both an environmentally safe and economically viable option. But on higher concentration, it caused inhibition in seed germination and partial or complete wilted growth of plants due to the presence of heavy metals. These possible drawbacks of leachate as liquid fertilizer were due to the high content of solids, metals and salt which could be simply overcome by dilution. Dosage should be adjusted according to the crop requirement. Overall this might lower the dependence on synthetic fertilizer and provide an opportunity for environmentally friendly reuse of leachate through the application of practical nutrient recycling techniques in agriculture. It can be concluded based on this study results through proper management and quality parameters and periodic soil fertility monitoring of leachate is safe, long term, and successful reuse as liquid fertilizer can be ensured.

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RECCOMENDATIONS

 Long term research should be undertaken on heavy metal accumulation and soil properties before large scale application of leachate as soil fertilizer.

 Detailed analysis of leachate should be done such as phenolic compounds, C/N ratio, organic carbon etc.

 Comparative study should be undertaken on the fertilizing qualities of organic and inorganic fertilizer and leachate

 Dilution is necessary forlowering the negative impacts of leachate irrigation, according to this study irrigated with 1%-3% (aprox. 2030ml/L) solutions showed higher yields than similar plants irrigated with tap water. For applying leachate on other crops dilution factor should be set according to their needs.

 Seasonal variation and waste composition affect the leachate composition so research should be undertaken on that and necessary action should be taken for the uniformity of basic nutrients of leachate.

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