Assessing Suitability of Leachates from Watermelon (*Citrullus lanatus*) Wastes for Use in Soil Amendment in Relation to Heavy Metal Levels

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Abstract

Watermelon fruits are widely consumed across Nigeria. The resultant wastes, though biodegradable, can be converted to useful soil amendment components for enhanced food crop production. This study investigated levels of nine heavy metals to ascertain suitability in terms of safety. Freshly harvested fruits that were grown in greenhouse environment were used to generate leachates. The concentrations of copper (Cu), cadmium (Cd), nickel (Ni), lead (Pb), zinc (Zn), manganese (Mn), barium (Ba) and mercury (Hg) were determined using Atomic Absorption Spectrophotometer (AAS) at 10 replicates per metal. Results showed that metal level increased in the order: Zn > Mn > Ni > Pb > Cu > Cd > Cr and none was above the stipulated threshold. Barium and Hg were not detected. Being grown within the same environment, there was no significant ($p \leq 05$) difference among metal levels in leachates generated for the different fruits. Study revealed that it is safe to recycle water melon wastes derived from fruits grown in non-polluted soils as soil amendment component.

Key words: *Leachate Quality, Water Melon, Heavy Metals, Soil Amendment, Environment*

1. Introduction

Sustainable leachate reuse is one of the strategies that should contribute to sustainable food production value chain. Watermelon (*Citrullus lanatus*), is a fruit crop reported to have up to about 92 % water content (Hoffmann-Sommergruber & Bruckmüller, 2009), hence a potential resource for leachate generation reuse. It is a widely consumed fruit, whose production is up to the tune of 66,196 tonnes per annum in Nigeria (Abubakar et al, 2020). Watermelon has the potential to yield large biomass, which can be converted to useful resource material for enhanced food crop production. It is, however, necessary to ensure environmental safety in its leachate reuse. The aim of this study, therefore, was to conduct preliminary investigation on the safety of the reuse of leachate generated from watermelon waste collected at point of generation (source – segregated

waste). The levels of these selected heavy metals: Zn, Cr, Mn, Cu, Pb, Cd, Ni, Ba and Hg in leachates generated from source - segregated watermelon waste were assessed to give insight on the suitability of the leachates for reuse as soil amendment components for enhanced crop production.

2. Materials and Methods

2.1 Generation of Leachate from Watermelon Waste

Freshly harvested fruits grown in greenhouse environment of Golden Food Project, Federal University Otuoke were used to generate leachates. After consumption of the harvested watermelon fruits, the waste materials were prepared for leachate generation by cutting into cubes and stored in 10 different plastic wares (5L capacity), labelled A to J. Three liters of deionized water were added to the mixture and allowed to stand for 4 weeks in order to facilitate effective leachates formation. The already formed leachate was filtered and the filtrate was then sent to a certified chemical laboratory (Anal Concept Limited, Elelenwo, Port Harcourt) where heavy metal analysis was carried out on the leachates.

2.2 Determination of Heavy Metals in Leachate Samples

In order to ascertain the suitability of the leachates in terms of safety, for reuse especially in soil amendment purposes, nine heavy metals were investigated. The leachate samples were subjected to wet acid digestion. The concentrations of Cu, Cd, Ni, Pb, Zn, Mn, Ba and Hg were determined using Atomic Absorption Spectrophotometer (AAS) at n=10. The levels of these metals in the soils used for crop production were also determined. Standard quality control and quality assurance procedures were followed.

2.3 Statistical Analysis

Data generated from this study were subjected to statistical analysis using SPSS package (version 22) for descriptive and inter-element correlations.

3. Results and Discussion

Results showed that metal concentrations increased in the order Zn > Mn > Ni > Pb > Cu > Cd > Cr as shown in Fig. 1. The scarcity of literature and data on acceptable limit of these metals in leachate generated from watermelon necessitated the use of acceptable standards for irrigation water for crop farms as stipulated by WHO (2001).

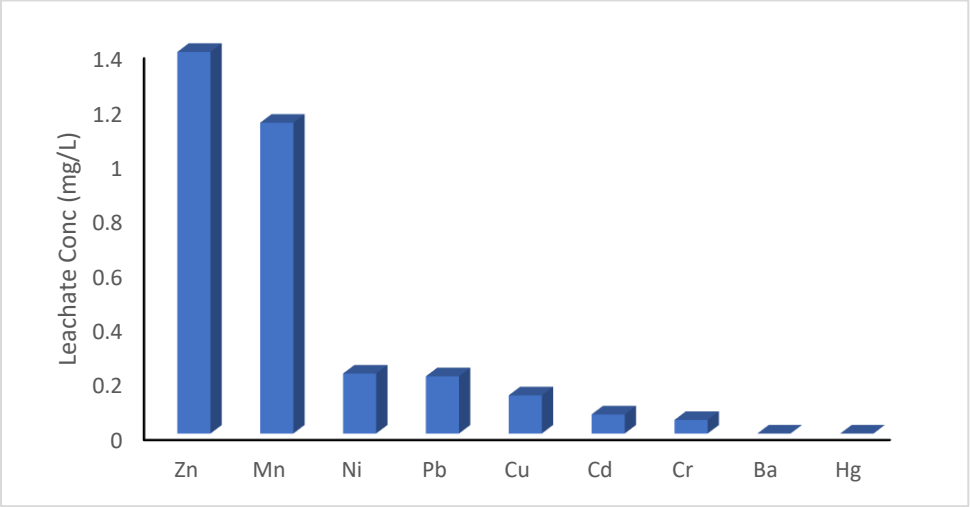

Fig. 1: Metal Concentrations in Watermelon Leachates

3.1 Zinc

Zinc concentration ranged from 0.09 to 0.19 mg/kg with a mean value of 0.14 ± 0.02 mg/kg, which is within the acceptable limit of 2.00mg/kg for Zn in leachates. Zinc is an important micro-nutrient element for plant that perform key cellular functions such as metabolic and physiological processes, enzyme activation and Fe homeostasis (Saleem et al, 2022). However, high concentration of Zn can cause toxicity to plants including stunting of shoots, curling and rolling of young leaves, death of leaf tips and chlorosis. It is important therefore, to ensure that limits are not exceeded.

3.2 Manganese

Manganese concentration varied from 0.11 to 0.12 mg/kg with a mean of 0.114 ± 0.002 mg/kg, which is within the acceptable range for Mn in leachate generated from watermelon. Manganese in elevated concentration can be toxic to sensitive crops especially those grown in soils with pH below 5.0. Mn is a plant essential element, very critical for photosynthesis. It acts as an activator for enzymes in growth processes and increases crop availability of nitrates by converting nitrates to a form of nitrogen that can be readily be utilized by the crop.

3.3 Copper

Copper was obtained in the range of 0.12 to 0.15 mg/kg with a mean of 0.141 ± 0.004 mg/kg and is within the acceptable threshold of 0.20 mg/kg of Cu in the leachate generated from watermelon. Copper is an essential element for plant growth. Inadequate level of Cu can cause poor growth, delayed flowering and plant sterility. It is, therefore, desirable that soil is enriched with copper within the acceptable limit (Bambara et al, 2015; Maleki et al, 2013). The presence of Cu in watermelon leachate is a good development in that it has the potential to act a good organic fertilizer in terms of soil – copper supplement.

3.4 Nickel

Nickel concentration ranged from 0.18 to 0.27 mg/kg mg/kg with a mean of 0.217 ± 0.008 mg/kg, which is within the acceptable range for Ni generated in watermelon. Ni is a potentially toxic metal that is present in all soils within an average concentration of 20 to 30 mg/kg. Its presence in the leachate would have been as a result of soil – plant translocation mechanism because the element (Ni) was detected in the soil where the watermelon was grown. Although the concentrations of Ni found in the leachates were within permissible limit, it is advisable to ensure that the soil where watermelon is grown should have very low or little concentration of Ni because of high mobility of the element from soil to plant (Osu and Isaac, 2014; Yusuf et al, 2011).

3.5 Cadmium

Concentration for Cd was obtained in the range of 0.007 to 0.008 mg/kg with a mean value of 0.0072 ± 0.00 mg/kg. This is within the acceptable range of 0.010 mg/kg for Cd in leachates generated from watermelon. Cd makes up about 0.1ppm of earth crust and is used in many products including batteries, pigments, metal coatings, plastics and even in cigarettes smokes. In plants, elevated concentration of cadmium reduces uptake and translocation of nutrient and water, increases oxidative damage, disrupt plants metabolism and inhibits plants morphology and physiology (Haider et al, 2021; Bambara et al, 2015).

3.6 Chromium

Chromium was obtained in the range of 0.03 to 0.09 mg/kg with a mean of 0.051 ± 0.006 mg/kg. Similar to the case of the previous metals, this is within the acceptable threshold of 0.10 mg/kg for Cr in the leachate. Naturally occurring chromium are usually found in the trivalent state (Bhalerao, 2015). Soil Cr pollution poses environmental problem. Farmland chromium pollution is a threat to safety of agricultural products and human health and safety via food chain. Result indicate that the use of watermelon leachate as soil amendment component poses no threat either to the soil or crop or public health.

3.7 Lead

Lead concentration ranged from 0.12 to 0.35 mg/kg with a mean of 0.213 ± 0.023 mg/kg, which is within the threshold of 5.00 mg/kg for Pb generated in watermelon. Pb occurs normally in soils but has no known benefit to human health. It has the potential to cause irreversible neurological damage in addition to renal, cardiovascular and reproductive toxicity. Hence, its occurrence within the acceptable limit in the leachate is a welcome development.

3.8 Barium and Mercury

Barium and mercury were not detected in the leachate. This is a good development because the leachate would pose no potential barium stress to any plant grown in the soil where watermelon waste especially leachate is used as soil amendment. Their elevated concentration is a potential risk to plant safety.

Generally, most heavy metals occur naturally in the environment but their elevated concentration above the threshold poses environmental risk and public health hazards (Myrvang et al, 2016; Sleimi et al, 2021). There is significant inter-element correlations between Cd and Cu ($r = -0.708$, $p < 0.05$), Cd and Ni ($r = 0.661$, $p < 0.05$), Pb and Zn ($r = 0.779$, $p < 0.05$), Ni and Mn ($r = -0.633$, $p = 0.05$), Zn and Cu ($r = 0.826$, $p < 0.05$), Zn and Mn ($r = 0.852$, $p < 0.05$), and Mn and Pb ($r = 0.649$, $p < 0.05$), where r stands for correlation coefficient. Results revealed synergistic relationship between Cd and Ni, Zn versus Pb, Cu and Mn. However, antagonistic relationship was identified for Cd versus Cu, Ni versus Mn.

4. Conclusions

Barium and mercury were not detected in the leachate. Zn, Cu, Cr and Mn which are plant essential nutrient elements were found within the acceptable limits. Pb, Cd and Ni were detected but in safe concentration ranges. In general, the concentration of the metals was either not detected for mercury and Ba or were found within acceptable limits for Zn, Cu, Cr, Ni, Mn, Pb, Cd. Study revealed that watermelon waste is source-segregated and is a good natural resource material for use in soil amendment for enhanced crop growth and productivity. It is recommended that further studies be conducted to explore its potential in the formulation organic fertilizer. Study revealed that it is safe to recycle water melon wastes derived from fruits grown in non-polluted soils as soil amendment component.

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