Facultad de Ingeniería
ISSN: 0121-1129
ISSN: 2357-5328
revista.ingenieria@uptc.edu.co
Universidad Pedagógica y Tecnológica de Colombia
Colombia

Santacoloma-Londoño, Sandra; Buitrago-González, María-Eugenia; Colorado-Molina, Karen; Suárez-Pineda, Isabella; Martínez-Martina, Mónica-Andrea; Villegas-Méndez, Luis-Carlos
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Facultad de Ingeniería, vol. 29, no. 54, 2020, -March
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DOI: https://doi.org/10.19053/01211129.v29.n54.2020.10666

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Citation: S. Santacoloma-Londoño, M.-E. Buitrago-González, K. Colorado-Molina, I. Suárez-Pineda, M.-A. Martínez-Martina, and L.-C. Villegas-Méndez, "Agricultural Use of Biosolids Generated in Wastewater Treatment of a Food Industry," *Revista Facultad de Ingeniería*, vol. 29 (54), e10666, 2020. https://doi.org/10.19053/01211129.v29.n54.2020.10666

Received: January 28, 2020; **Accepted:** March 16, 2020; **Published:** March 28, 2020

Competing interests: The authors have declared that no competing interests exist.

Agricultural Use of Biosolids Generated in Wastewater Treatment of a Food Industry

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Abstract

Biosolids generated as waste from a Wastewater Treatment Plant (WTP) are a pollution problem by the provision of large volumes in landfills and the waste of their potential as an agricultural input. The research conducted trials to analyze the agricultural use of biosolids in a food company's WTP, their effects on the germination and development of the vegetal plant species *Coriandrum sativum* were assessed through trials that mixed different amounts of biosolids, land soil and commercial fertilizer, and took into account: planting site characteristics, biosolid and *Coriandrum sativum*. A random block design was made to compare treatments understudy and resulted in the combination of 50% biosolids with 50% land soil was the best test by germination, height, mass and length of the roots of the plant studied. In the evaluation of results, the behavior of dependent variables was analyzed:

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germination, height, mass and length with respect to the four test types with their respective repetitions using ANOVA and Fisher's significant minimum difference (LSD) to determine the effect the biosolid had on the plant and to know the optimal dose for its development. The germination rate (GR) was also determined in the trials, and 98.3% was found for the best treatment indicating that the substrate does not contain phytotoxic elements.

Keywords: biosolid; block design; *Coriandrum sativum*; germination; organic fertilizer; wastewater.

Uso agrícola de biosólidos generados en el tratamiento de agua residual de una industria de alimentos

Resumen

Los biosólidos generados como residuo de una Planta de Tratamiento de Aguas Residuales (PTAR) son un problema de contaminación por la disposición de grandes volúmenes en los rellenos sanitarios y el desperdicio de su potencial como insumo agrícola. En la investigación se realizaron ensayos para analizar el uso agrícola de los biosólidos de la PTAR de una empresa de alimentos; se evaluaron efectos en la germinación y desarrollo de la especie vegetal *Coriandrum sativum* mediante ensayos que mezclaron diferentes cantidades de biosólidos, suelo del terreno y fertilizante comercial, y se tuvieron en cuenta: características del lugar de siembra, del biosólido y de *Coriandrum sativum*. Se hizo diseño de bloques al azar para comparar los tratamientos bajo estudio y se obtuvo como resultado que la combinación de 50% biosólidos con 50% suelo del terreno fue el mejor ensayo por germinación, altura, masa y longitud de las raíces de la planta estudiada. En la evaluación de resultados se analizó el comportamiento de las variables dependientes: germinación, altura, masa y longitud con respecto a los cuatro tipos de ensayo con sus respectivas repeticiones mediante ANOVA y diferencia mínima significativa (LSD) de Fisher para determinar el efecto que tuvo el biosólido sobre la planta y conocer la dosis óptima para su desarrollo. También se determinó el índice de germinación (IG) en los ensayos, y se encontró para el mejor tratamiento 98.3% que indica que el sustrato no contiene elementos fitotóxicos.

Palabras clave: agua residual; biosólido; *Coriandrum sativum*; diseño de bloques; fertilizante orgánico; germinación.

Uso agrícola de biosólidos gerados no tratamento de água residual de uma indústria de alimentos

Resumo

Os biosólidos gerados como resíduo de uma Planta de Tratamento de Águas Residuais (PTAR) são um problema de contaminação pela disposição de grandes volumes nos aterros sanitários e o desperdício de seu potencial como insumo agrícola. Na pesquisa realizaram-se ensaios para analisar o uso agrícola dos biosólidos da PTAR de uma empresa de alimentos; avaliaram-se efeitos na germinação e desenvolvimento da espécie vegetal *Coriandrum sativum* mediante ensaios que misturaram diferentes quantidades de biosólidos, solo do terreno e fertilizante comercial, e levaram-se em conta: características do lugar de plantio, do biosólido e de *Coriandrum sativum*. Desenharam-se blocos aleatoriamente para comparar os tratamentos sob estudo e obteve-se como resultado que a combinação de 50% biosólidos com 50% solo do terreno foi o melhor ensaio por germinação, altura, massa e longitude das raízes da planta estudada. Na avaliação de resultados analisou-se o comportamento das variáveis dependentes: germinação, altura, massa e longitude, com respeito aos quatro tipos de ensaio com suas respectivas repetições mediante ANOVA e diferença mínima significativa (LSD) de Fisher para determinar o efeito que teve o biosólido sobre a planta e conhecer a dose ideal para seu desenvolvimento. Também se determinou o índice de germinação (IG) nos ensaios, e encontrou-se para o melhor tratamento 98,3% que indica que o substrato não contém elementos fitotóxicos.

Palavras chave: água residual; biosólido; *Coriandrum sativum*; desenho de blocos; fertilizante orgânico; germinação.

I. INTRODUCTION

Any human activity that requires water generates liquid waste known as wastewater, which is classified according to its origin in industrial, agricultural-livestock and domestic. This wastewater must be treated in order to partially or fully being rejoined [1]. Such treatment generates by-products known as waste sludge, which are solid, semi-solid or liquid residue [2]; its composition depends mainly on the characteristics of the effluent wastewater and the treatment process used in the plant that generates it [3].

The volume of sludge produced depends on the characteristics of wastewater, pre-treatment, sedimentation time, solid density, and moisture content, type of sludge removal equipment or method, and frequency of removal [4,5]. The sludge can contain a large number of pathogens, depending on the treatment processes used [6]. The most important pathogens that exist in water and have been found in sludge are bacteria (such as Salmonella), viruses (mainly enterovirus), protozoa, trematodes, baskets and nematodes [7] that can spread diseases if you have direct contact with them.

As for the composition of biosolids, it is a mixture of nitrogen-rich organic compounds, and commonly present a low carbon-to-nitrogen ratio (C/N) [8]. In addition, there are factors that influence their quality as is the case of metals, these being mainly: Zinc (Zn), Copper (Cu), Nickel (Ni), Cadmium (Cd), Lead (Pb), Mercury (Hg) and Chromium (Cr) [9]. Its potential for accumulation in human tissues and its biomagnification are characteristics that generate concern; metals are present in low concentrations in domestic wastewater, but high concentrations are mainly found in industrial wastewater [10].

The current concern, in relation to sludge is to try to reduce their volume and that the compounds and elements they contain are in concentrations that allow them to be managed without problems or negative environmental impacts [3, 11]. Estimates of the global production rate of biosolids are in the order of 25 to 60 million tons of dry solids per year [12] with much of this applied to soil [13]. Because biosolids are rich in nutrients, their application in the soil as fertilizer is an attractive option for sustainable soil nutrient management and carbon sequestration [14].

As for the agronomic composition of the sludge, characteristics similar to those usual in a commercial fertilizer are taken into account, with the nutrients and trace elements necessary for the correct development of plants [15]. The elements that confer these properties are Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), some metals in certain amounts (Zinc (Zn) and Copper (Cu)) and humid organic compounds [16, 17].

From a practical point of view, sludge is a source of organic carbon, N, P, as well as some inorganic compounds such as silicates, aluminates, and so on, which can be recycled and used for industrial or agricultural purposes [12].

The term biosolid is the product resulting from the stabilization of the organic materials (sludges) generated in the treatment of wastewater, with physical, chemical and microbiological characteristics that allow being reused with restriction according to with the regulations of each country. An example of reuse is its return to the ground for the supply of nutrients and organic matter [18].

The quality of biosolids depends mainly on four groups of contaminants: Pathogens, Heavy metals, Nutrients and organic pollutants [19]. Agricultural use has become the main method of removing sewage sludge [20]. Statistics show that between 40% and 50% of dry sludge is used in agriculture [21]. Approximately 7% to 22% of the dried sludge produced by the European Union and the United States respectively are treated with incineration or thermal drying. Between 14 and 17% of sludge produced is use for landfill [22], while 12% is used in other areas such as forestry, soil recovery, among others. The use of the sludge as input for growing vegetables becomes the best option, because, due to its properties, it gives agricultural practices management of nutrients in their crops that allow reducing the environmental impact that is generated with the use of chemical fertilizers [23]. In addition to those mentioned, there are other possibilities, some of them derived from the above, such as the restoration of quarries, and others such as the use of sludge, after different treatments, in the manufacture of building materials and even, as an animal feed by obtaining proteins [24].

Currently, it is common to incorporate waste sludge in agricultural soils, as it reduces the addition of commercial fertilizers, improves their fertility, increases water retention capacity and reduces soil erosion [25]. Sludge acts as a soil conditioner to facilitate the transfer or provide nutrients, increase water retention and improve soil fitness for cultivation [26]. Sludge also serves as a partial substitute for expensive chemical fertilizers [4]. Sewage sludge is a renewable resource that contains important nutrients that can be used to replace fertilizers made from fossil fuels [27] but need to be treated in advance appropriately.

The main objective of this work was to study the use of sludge generated in wastewater treatment when used as an agricultural input in various concentrations. It was used for the planting of a fast-growing plant and compared its development in terms of germination, mass and length of the plant and roots with the use of fertilizer for commercial use and with a control sample.

II. Materials and Methods

For the development of this research, the following actions were carried out:

A. Identification of the Physical, Chemical and Microbiological Characteristics of Residual Sludge

The following analyses were performed in a certified laboratory:

• Nitrogen Characterization ($N\text{-}NH_4$, $N\text{-}NO_3$, $N\text{-}NO_2$)

• COT, N-total, Ca, Mg, K, Total Mn, Total Cu, Total Zn, Total B, Total S.

• Composition of heavy metals (As, Cd, Cu, Hg, Mb, Ni, Pb, Se, Zn) and their reactivity, corrosivity, flammability, toxicity and ecotoxicity.

• Total Coliforms, aerobic mesophiles, salmonella, E. Coli, molds and yeasts.

B. Implementation of the Pilot Trial

The choice of the plant was made considering factors such as the ease of obtaining the seed, the climate which the study area counts with and the time which the plant germinates and grows in.

To start the test, the terrain is searched and the exact area where the blocks will be made is chosen, for this, it was taken into account that all the blocks were exposed

L-ISSN: 0121-1129, e-ISSN: 2357-5328, DOI: https://doi.org/10.19053/01211129.v29.n54.2020.10666

to the same conditions of temperature, shadow, and slope, among others. The terrain is shown in Fig. 1.

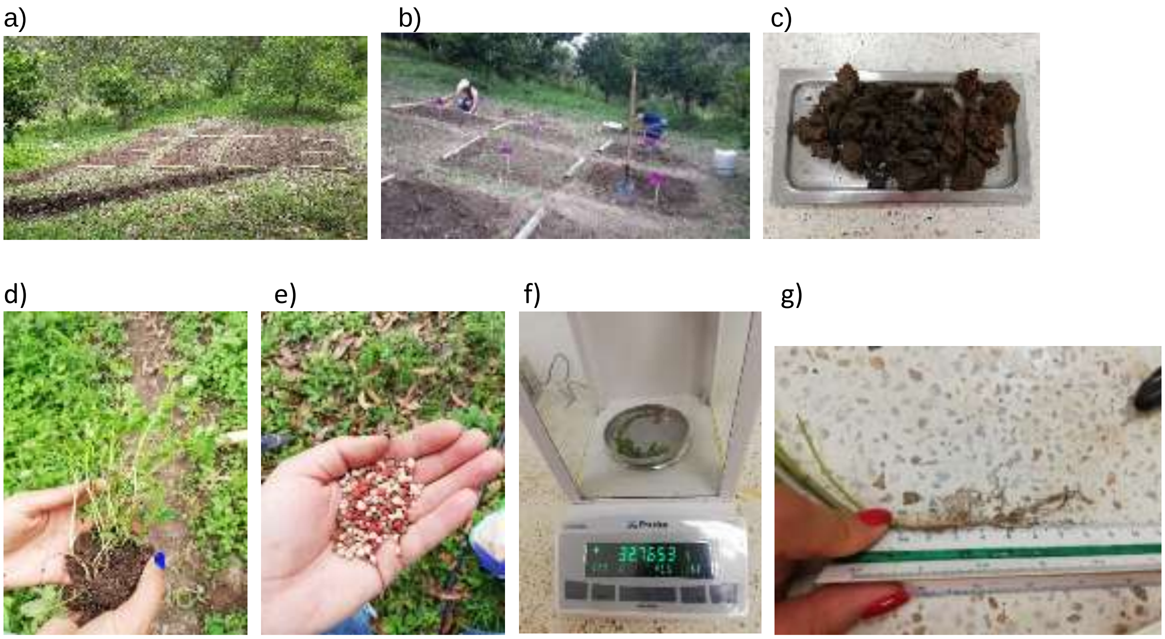

Fig. 1. Images of test: a) terrain by blocks, b) signaling for treatments, c) sludge for treatments, d) *Coriandrum sativum* obtained after 30 days, e) fertilizer NPK used, f) plant mass measurement, g) plant root length measurement after 30 days.

A planting area was selected, taking a bearing in mind the environmental factors of the site, such as; temperature, humidity, sun exposure, soil type, etc. Based on these factors, the type of plant was *Coriandrum sativum* [28].

The effect of 3 independent variables (50% and 100% biosolid concentration and NPK fertilizer known as Triple 15) was studied on the dependent variables (% germination, height, number of leaves, root length, and mass). This design sought to make constant all environmental factors that could affect dependent variables to be certain of the effect that independent variables cause. For the addition of sludge, the phenology of the plant (germination and harvesting period) was taken into consideration. Different amounts of sludge were used, indicating four types of treatment:

• Treatment 1 (T_1): Composed of the soil of the ground (test control).

• Treatment 2 (T_2): 100% Sludge compound.

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• Treatment 3 (T_3): Composed of 50% sludge + 50% soil of the ground.

• Treatment 4 (T_4): Composed of the soil of the ground + commercial fertilizer NPK.

C. Random Block Design

The use of this design allows comparing the treatments under study. The selection of each treatment was the sort to define its respective location in each block [29, 30, 31]. Table 1 shows the random complete block design that was used. Measurements of dependent variables were developed 15 and 30 days after planting (dap).

Table 1. Schema of the essay.

Block	Treatment			
1	T_4	T_2	T_1	T_3
2	T_1	T_3	T_2	T_4
3	T_1	T_4	T_3	T_2

T_1: Control test T_2: 100% sludge T_3: 50% sludge + 50% soil T_4: Soil + fertilizer

D. Technical Specifications of the Test

• Each block had the following dimensions: Width: 1 m; Length: 5.5 m.

• Each block was divide into 4 rows, and each row had the following dimensions: Width: 1 m; Length 1 m.

• The space between each row is call groove; each groove had 0.50 m, with three grooves per block.

• The distance between each block was 0.50 m, to have space when making the respective observations.

• Each row had four rows per treatment, the distance between each of the rows was 0.25 m, and the distance between plants (hole) had about 0.05 m.

• The seeds chosen had % germination of 70% and because they were a little low, 3 seeds were used for each planting hole.

• For each treatment, ground beds were made, about 0.10 m wide, as the seeds are small.

• Each treatment was marked, indicating the type of treatment (T_1, T_2, T_3, T_4). As shown in Fig. 1

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• Irrigation was performing daily, with the use of a hose.

E. Determination of Effect Results in Biometric Variables of Coriandrum Sativum

The evaluation frequency was as follows: one at 5 days after planting and then every 15 days for a 1-month time period. The parameters to be determined were as follows:

• Percentage (%) germination: In each experimental unit, the number of seeds germinated on the total sown was assessed.

• Plant height: Height from the base of the stem to the highest branch.

• Root Length: The length of the roots of each plant is measured.

• Number of leaves: at 15 dap (days after planting), 30 days after planting were counted the number of leaves per plant.

The number of data taken at 15 dap was as follows:

- % Germination: 10 data per treatment, 40 data per block and 120 data in total.
- Height: 5 data per processing, 20 data per block and 60 data in total
- Number of sheets: 5 data per processing, 20 data per block and 60 data in total.

At 30 days after planting, five data per processing took for 20 data per block to the following dependent variables:

- Height
- Number of sheets
- Root length
- Seedling mass

F. Assessment of Information

Photographic record (Fig. 1), observations were made and analysis of a factor's ANOVA variance, means table, and data dispersion was performed.

The hypothesis on which work was made was that the variation between sludge concentrations affects the test-dependent variables.

The ANOVA analysis raises two hypotheses: H_o: null hypothesis and Ha: an alternative hypothesis. The H_o states that there were no effects of the independent

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variable on dependent variables; i.e. the different concentrations of mud in the tests have no effect on germination, mass, height and length.

The H_a states that if there were effects of the independent variable on dependent variables; i.e. the different concentrations if they had an effect.

As an interpretation of the results, it is that when $P<0.05$ the alternative hypothesis is accepted and when $P>0.05$ the null hypothesis is accepted.

The Germination index (GI) of Zucconi was also determined to evaluate the germination and growth of fast response plant seeds that was obtained by multiplying the germination percentage and the percentage of root growth, both relative to control (Equation 1).

$$GI\ (\%) = \%\, G\ \times \%\, RL \qquad (1)$$

Since, GI: Germination Index; G: Germination, and RL: Root Length.

According to [32, 33] when the GI values are greater than 80%, the substrate does not contain phytotoxic elements; GI values between 80 and 50% indicate moderate presence, while values below 50% reveal a strong presence of phytotoxins.

III. Results

The chemical and microbiological characteristics of the sludge were identified and the results presented in Tables 2, 3, 4 y 5.

Table 2. Nitrogen Characterization of sludge.

Parameter	N-NH_4	NH_4	N-NO_3	NO_3	N-NO_2	NO_2
Expressed as	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Result	2878	3690	124	537	1.15	3.78

Table 3. Characterization of sludge.

Parameter	COT	N	P	Ca	Mg	K	Fe	Mn	Cu	B	S
Expressed as	g/kg	g/kg	g/kg	g/kg	g/kg	g/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Result	328	30.4	6.08	7.64	3.10	6.48	41314	529	262	36.09	6288

Table 4. Results of Characterization of sludge comparated with colombian legislation.

Parameter	**Expressed as**	**Results**	**Decree 1076 of 2015 Title 6 Section 3 (Colombia). Value max**
Corrosivity (pH)	Unidades	5.8	< 2.0 or >12.5
Inflamability	-	No inflamable	Non-flammable
Reactivity	L/kg*H	<0.1	Velocity < 1.0 L/Kg*H

Parameter	Expressed as	Results	Decree 1076 of 2015 Title 6 Section 3 (Colombia). Value max
Barium	mg Ba/L	0.19	100
Chrome	mg Cr/L	<0.1	5.0
Arsenic	mg As/L	<0,001	5.0
Silver	mg Ag/L	<0.1	5.0
Cadmium	mg Cd/L	<0.006	1.0
Selenium	mg Se/L	<0.001	1.0
Lead	mg Pb/L	<0.01	5.0
Mercury	mg Hg/L	0.03	0.2
Cyanide	mg/Kg	0.072	-
Sulfur	mg/Kg	60.67	-
Antimony	mg/L	<0.001	-
Beryllium	mg/L	<0.001	-
Copper	mg/L	0.05	-
Thallium	mg/L	0.02	-
Zinc	mg/L	0.12	-
Acute Toxicity (48 hours)	%	38.3	< 50

Table 5. Microbiological features of sludge.

Parameter	Results	Decree 1287 of 2014 (Colombia). Value max
Total aerobic count mesophiles CFU/g	500.000	-
Mold and Yeast Count CFU/g	12.000	-
Total Coliform Count CFU/g	19.000	1.000
E. Coli Count CFU/g	<1.000	1.000
Salmonella detection Ssp/25g	Absence	Absence

With respect to the trials, it was evaluated at 15 and 30 days after planting. Results were obtained from the trials at 15 days after planting (dap), and 30 dap. Then proceeded with the statistical validation of the data obtained and the synthesis presented below in Tables 6-9.

Table 6. Plant % germination by treatment.

Block	Results by Treatment (% Germination)			
	T_1	T_2	T_3	T_4
1	70.0	60.0	64.0	62.0
2	36.0	60.0	82.0	58.0
3	84.0	70.0	78.0	70.0
% Germination average	63.3	63.3	74.7	63.3

T_1: Control test T_2: 100% sludge T_3: 50% sludge + 50% soil T_4: Soil graund+ fertilizer

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Table 7. Plant Height by treatment.

Block	Results by Treatment Heigth (x 10^{-2} m)			
	T_1	T_2	T_3	T_4
1	7.7	10.6	10.9	8.2
2	6.4	13.0	11.6	10.8
3	8.6	9.6	10.6	7.9
Heigth average	7.6	11.1	11.0	9.0

T_1: Control test T_2: 100% sludge T_3: 50% sludge + 50% soil T_4: Soil graund+ fertilizer

Table 8. Mass of seedlings by treatment.

Block	Results by Treatment Mass of seedlings (x 10^{-3} kg)			
	T_1	T_2	T_3	T_4
1	0.436	0.902	1.280	0.342
2	0.464	0.712	1.238	0.886
3	0.414	0.712	0.608	0.410
Mass average	0.438	0.775	1.042	0.546

T_1: Control test T_2: 100% sludge T_3: 50% sludge + 50% soil T_4: Soil graund+ fertilizer

Table 9. Rooth length by treatment.

Block	Results by Treatment Rooth Length (x 10^{-2} m)			
	T_1	T_2	T_3	T_4
1	7.4	7.2	7.1	6.8
2	7.5	8.1	6.3	6.4
3	6.0	7.2	7.2	6.4
Rooth length average	7.0	7.5	6.9	6.5

T_1: Control test T_2: 100% sludge T_3: 50% sludge + 50% soil T_4: Soil graund+ fertilizer

All results were analyzed by using ANOVA of one factor (Treatments 1, 2, 3 and 4) for the analyzed variables:

- Dependent variables: % germination, height, mass, root length
- Factor: Type of test Treatments 1, 2, 3 and 4.

In the analysis of variance of a factor for % germination, height, root length and mass of seedlings are compared with the 4 different levels of Test Type.

The F-test in the ANOVA table determines whether there are significant differences between the means (Table 10).

Table 10. ANOVA P-values for dependent variables.

Dependent Variable	**Value-P**
% germination	0.353
Height	0.000
Mass of seedlings	0.000
Root length	0.297

According to the simple ANOVA when $P<0.05$ the alternative hypothesis is accepted; that is, the test types T_1, T_2, T_3 and T_4 have effects on height and mass results. On the other hand when $P>0.05$ the null hypothesis is accepted; which states that there were no significant effects of the T_1, T_2, T_3 and T_4 test types on germination and root length. Following the results, Table 11 shows the average of the measurements of the dependent variables for each type of test.

Table 11. Average values for variables dependent according to the Test Type.

Type of test	**Average**				
	% Germination	**Height x 10^{-2} m**	**Mass, x 10^{-3} kg**	**Root Length x 10^{-2} m**	**Germination index (GI) %G x %RL**
T_1	66.7	7.57	0.431	6.97	100
T_2	64.0	10.9	0.775	7.49	96.0
T_3	77.3	11.0	1.045	6.85	98.3
T_4	65.3	8.97	0.546	6.52	91.6
Average	68.3	9.63	0.699	6.96	95.3
Standard Error	5.79	0.459	0.069	0.357	

T_1: Control test T_2: 100% sludge T_3: 50% sludge + 50% soil T_4: Soil soil + fertilizer

Figure 2 show the behavior of the variables measured by each treatment.

L-ISSN: 0121-1129, e-ISSN: 2357-5328, DOI: https://doi.org/10.19053/01211129.v29.n54.2020.10666

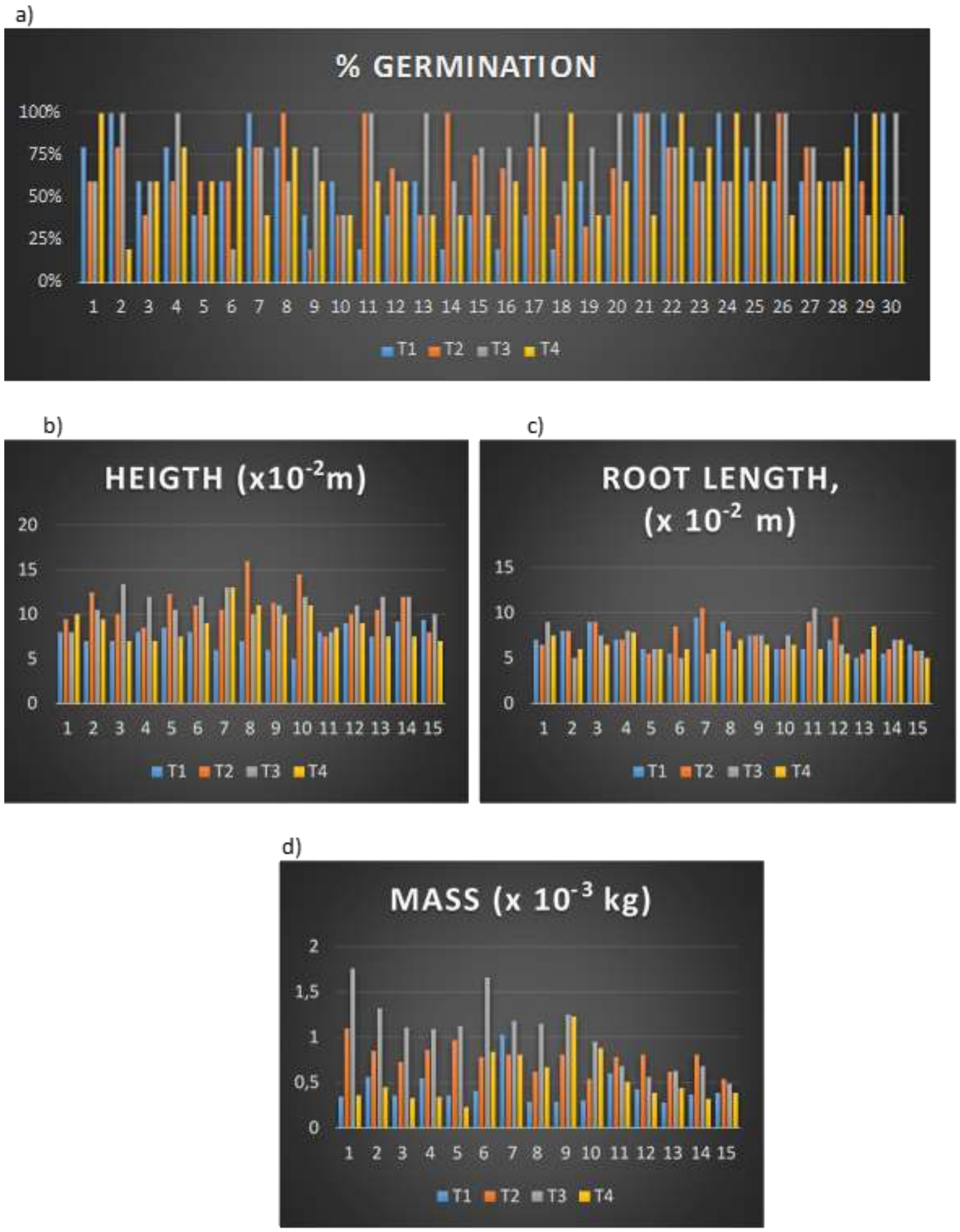

Fig. 2. a) % germination by treatment, b) heigth by treatment, c) root length by Treatment, d) mass by treatment.

It is note that T_3, yielded the best values on average in terms of germination, mass and height of plants. Those results were also above the control test (T_1).

The intervals obtained are based on Fisher's Low Significant Difference (LSD) procedure and are included in Fig. 3.

The Fig. 3 shows that germination was favored in T_3 with more than 10 percentage points from Control.

In terms of height, the mean values for T_2 and T_3 were very similar, but when analyzing the dispersion of the obtained data, the T_2 data are dispersed between 7.5 and 16 while the T_3 data disperse between 8 and 13.5 and turns out to be more reliable because it is not so scattered.

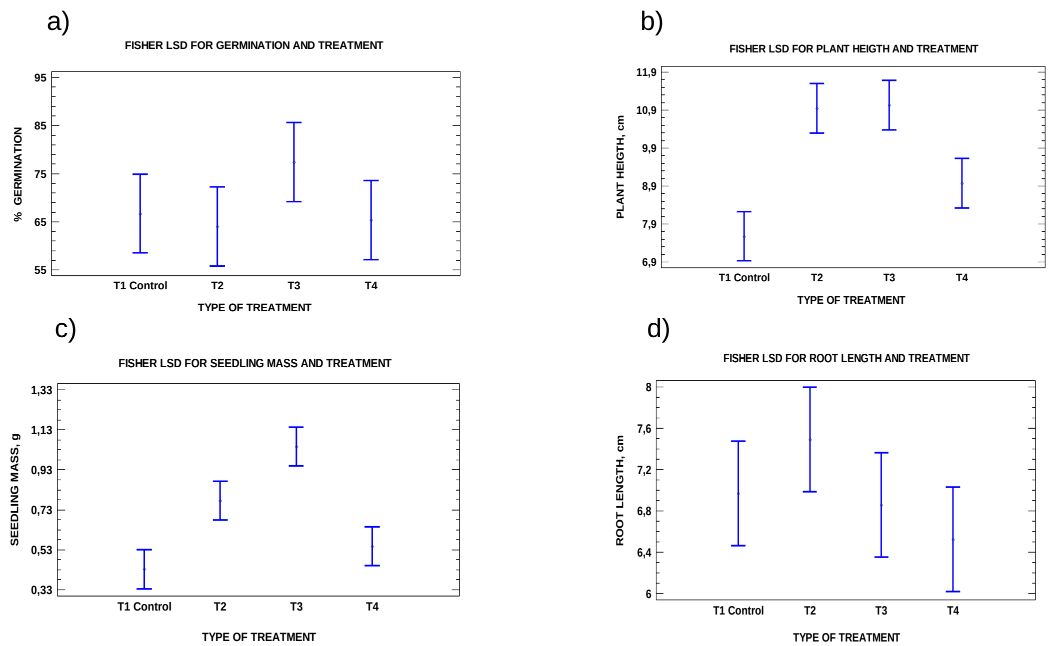

Fig. 3. Average and interval 95% of Fisher LSD for: a) % Germination, b) Height, c) Mass, d) Root length.

T_3 yielded on average the best value for mass, followed by T_2. When analyzing the dispersion of data for T_2 and T_3 that obtained on average the best values, 1.045 and 0.775 respectively, the T_3 values between 0.5 and 1.7 compared to those of T_2 between 0.55 and 1.1 were more dispersed. These results highlight the T_2 as it is more reliable in this case.

The T_2 yielded on average the best value for the length, followed by the T_4. When analyzing the information obtained according to the data dispersion for T_2 and T_4 that obtained on average the best values, 7.4 and 7.0 respectively, the T_2 values between 5.6 and 10.6 compared to those of T_2 between 5.0 and 9.5 were more dispersed. These results highlight T_4 as it is more reliable in this case.

IV. DISCUSSION

The results of the characterization showed that: the sludge is not corrosive, is non-flammable and not reactive. Analysis of elements such as Bario, Chromium, Arsenic, Silver, Cadmium, Selenium, Lead and Mercury showed that they are below the permissible limits according to Colombian legislation, which is a favorable aspect.

With regard to microbiological analysis, the total Coliform count exceeds the maximum permissible value in Colombian law. With respect to microbiological analysis, the total Coliform count far exceeds the maximum permissible value in Colombian law. In addition, according to the analysis, it showed that the sludge analysed is considered non-ecotoxic.

It was found that at the biological level, in the germination test all substrates are an adequate option for seed germination, but in the substrate identified as T_3 treatment with 50% sludge + 50% soil, the best conditions were obtaining in terms of % germination and height of the *Coriandrum sativum* with a value of 77.3% ± 0.2 being this value even higher than the Control test which could be attributed to the nutritional power of the studied sludge. For % Germination, comparison with similar studies is shown in Table 12.

Table 12. Comparison of germination percentage values in different studies [34 - 36].

Origin of the substrate	% Germination	Plant sown
Company food wastewater treatment sludge	77.3	*Coriandrum sativum*
Municipal wastewater treatment sludge	76.3	*Daucus carota L*
Vermicomposted residual sludge humus	48.6	*Daucus carota L*
Residual sludge humus with vermicomposted	77.6	*Daucus carota L*
Wastewater sludge Brewing Industry Treated and Fermented	94.9	*Lactuca sativa*
Chicken breeding sludge	93.0	*Coriandrum sativum*
Fertilizer from organic waste (Bokashi)	84.0	*Coriandrum sativum*
Compost from Sourcing Center Fruits and Vegetables (CAVASA)	95.0	*Coriandrum sativum*
Urea	88.0	*Coriandrum sativum*

By comparing this value of 77.3% ± 0.2 with the study of [34] that using compost from Sourcing Center Fruits and Vegetables (CAVASA) obtained 95% efficiency in germination, it can be established that it is favorable to use as an agricultural input.

When calculating the GI (germination index) for the different tests taking into account germination and root length with respect to the Control test, The T_3 is placed 98.3% first indicating that the substrate does not contain phytotoxic elements; treatments 1 and 4 with values of 64.0 and 61.1% indicate a moderate presence of phytotoxins.

ANOVA concludes that the height and mass of seedlings were significantly affected by varying test types while % Germination and Root length were not affected by the type of test as for all cases there were germination comparable percentages.

Regarding germination, this study coincides with that of [35] working with brewery Wastewater Treatment Plant sludge, showed that for low sludge control and concentration tests there is no significant difference. There is also coincidence with this study that germination occurs because there are not phytotoxic effects of the sludge in the plant.

As for the microbiological composition of sludge, it could be observed that the levels obtained are too high which became an unfavorable aspect and that it is necessary to consider in case the use of the sludge as an agricultural input is implemented.

V. CONCLUSIONS

The characterization of sludge allows to establish their potential use according to the concentration of contaminants that affect their biodegradability depending on their toxicity; in this case, the analysis showed its feasibility as an agricultural input.

The use of completely random block design helped reduce and control the variance of experimental error; experimental units (T_1, T_2, T_3 and T_4) were relatively homogeneous with respect to factors that could affect response variables (germination, height, mass, and root length).

The use of wastewater treatment sludge is a favorable environmental aspect because it decreases the large amount that is carried to the landfill while taking advantage of its nutritional content.

In the case of the studied sludge, which is generated in wastewater treatment, its use as an agricultural input is a viable option and offers good results provided that it can be controlled that its nutrient content, its ecotoxicity, its microbiological conditions and Its content of corrosive and dangerous elements are below the maximum admissible levels for this use.

The combination of soil with raw sludge from wastewater treatment provides a stable, hummus-like organic material that can be used as a nutrient source for plant growth and development. It was found that the mixture of 50% soil + 50% sludge is the option that produced the best results for the growth and development of seedlings of the species *Coriandrum sativum.*

AUTHOR'S CONTRIBUTION

All the authors contributed in the construction and editing of this document from their different knowledge perspectives. Specifically, Santacoloma-Londoño developed the experimental and methodological design, developed the statistical analysis of the information collected and made the discussion of results. Buitrago-González consolidated the conceptual reference, made the identification of conditions of growth and development of the species used. Colorado-Molina and Suarez-Pineda developed fieldwork from field conditioning, implementation of block trials and measurements. Martinez-Martina guided the implementation of random block design and contributed to elaboration of document's conceptual reference. Villegas-Méndez supported the monitoring and evaluation the conditions of the plant used.

FUNDING

This research work was funded by the Higher Education Institution: Unidad Central del Valle del Cauca (UCEVA), Tulua- Colombia.

ACKNOWLEDGEMENTS

The authors thank Professor Heberth Caicedo Saldaña, Director of the research group - ILA- of the Program Foreign Languages of the UCEVA - Tuluá (Valle) Colombia for its support in the translation of this article.

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