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Effect of Mine Tailings on the Growth of Ornamental Plants

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Abstract- The researchers sought to determine the effect of mine tailings on the growth ornamental plants. The study aimed to evaluate the effects of mine tailings o n the numbers of seed germinated, number of leaves, length of seedlings and length of primary roots; assess the effects of the various percentages of mine tailings; determine the interaction effect of the various percentages of mine tailings with fertile soil and organic fertilizers; and establish the best kind of percentages of mine tailings on the germination of seeds and growth of seedlings. Experiments were performed to determine the germination and growth of petunia seeds. Selections of plant candidate from varieties of seeds were considered. The ideal candidate is petunia seeds since it can sprout at a minimum period of seven days. Generally, there is significant effect of mine tailing concentration in primary root growth . Findings show that primary roots in 25%, 50% and 75% mine tailings media are significantly shorter than the pure soil media. The data revealed that addition of fertilizer to the media increased plant growth in the three (3) media. There is significant increased in root lengths when fertilizer is added. It is also noted that there is significant decrease in root length as the amount of mine tailing is increased. The findings proved that the further development of plant organs are affected or are influenced by soil mineral concentrations. In this case , the mine tailings at any rate affect the leaves formation.

Index Terms- Mine tailings, ornamental plant growth, soil alternative

I. INTRODUCTION

Mine tailings (also called "slimes") are sand-like waste products of the mining process. In the early mining days, tailings were discarded in low-lying areas or lakes and streams near the mines. Over time, these tailings can move through the environment and may be redistributed over larger areas of land. Metals and other naturally occurring substances commonly found in the mine tailings include arsenic, mercury, cobalt, and nickel. Tailings sites can present both physical and chemical health hazards under certain exposure conditions. Where there is no exposure, there is no risk. This means that tailings that have been covered with topsoil and grass are less likely to be a health concern than tailings that are left uncovered.

Tailings are the waste materials produced from the extraction process used for obtaining ore. In the process of extracting the ore, the waste material is ground into particles with a typical grain-size distribution that ranges from medium sand to clay size particles. If the tailings are not treated or isolated, exposure to air and water will likely produce acid mine drainage. Tailings near the surface of an exposed pile will oxidize most readily, while tailings at depth will remain unoxidized.

For proposed operations, tailings samples are typically obtained from pilot plants which are small scale milling plants implemented before the large scale plant in order to test operational methods and to predict environmental impacts. Samples from pilot plants can be used for predictive testing (i.e. static and kinetic testing) to determine the acid generation potential of the tailings. During mining operations, samples may be taken from designated tailings piles to predict their acid generating potential, similar to that done before mining. After mining is complete, tailings samples are commonly taken during the following steps of the reclamation process: site assessment, removal and disposal, waste treatment, and monitoring and assessment (soil, vegetation, and water).

For abandoned mines, the tailings are often found distributed around a site and are not consolidated in designated piles. The tailings are found in stream bottoms and floodplains, in downstream lakes and rivers, near areas where mining took place, in areas where ore bodies were processed, and anywhere in between. It is often necessary to do intensive sampling during the site assessment phase at abandoned mine locations since often times, tailings are spatially widespread. In addition, site assessment sampling is important to characterize the site since there is often a lack of information available on abandoned mine sites from when mining activities were taking place.

Phytoremediation has probably a large potential for treatment of pollutants in the environment, even if today, plants are not widely used. Studies were conducted in order to determine technical and economical feasibility of phytoremediation processes for full-scale treatment, including rhizofiltration (use of plant to accumulate compounds from aqueous solutions into roots), phytostimulation (use of plant to stimulate naturally occurring microbial degradation), phytostabilization (use of plant to prevent compounds from mobilizing or leaching in soil) and phytoextraction (use of plant to remove contaminants from soils into plant roots or shoots). One of the greatest advantages of phytoremediation is its lower cost than other competing technologies.

In addition to cost, phytoremediation offers other advantages : it is a non destructive in-situ technology applicable to a variety of contaminants, it is capable of remediating the bioavailable fraction of pollutants and accumulating heavy metals (Cu, Co, Ni, Zn, Cd, Pb). On the other hand, treatment time is the biggest disadvantage, and 5 to 20 years may be needed in some cases for soil clean-up. Plants are seasonally dependent and hyperaccumulator plant species can also have a very low growth rate, making necessary to select new varieties capable of hyperaccumulation with high biomass production. Among disadvantages are the fact that phytoremediation is not applicable to mixed wastes or to high concentrations of pollutants. It also require large available surface area and it is applicable only to surface soils. One of the major problem is the need, in some cases, to harvest the biomass and to dispose it as hazardous waste. There is also a lack of recognized economic performance data and the potential market seems to be very confidential today. Further research and development efforts are then necessary to increase remediation performances and to reduce treatment time, especially for high concentration pollutions or complex pollutions with mixtures of heavy metals and/or organic compounds. These efforts could concern, for example, the optimization of plant growth and plant uptake (plant selection, cultivation techniques, fertilizers, harvesting techniques and the utilization of harvested biomass.

The research hopes to develop a simple, inexpensive and highly effective in situ remediation technique for inorganically contaminated soils, contaminated with heavy metals are recognized as a growing problem in many parts of the world, and phytoremediation may offer an alternative to destructive clean-up technologies. About 400 metal-accumulating wild plants that accumulate high concentrations of heavy metals in their shoots have been reported; however, their slow growth rate and limited yields impose limitations on the rate of heavy metal removal and make phytoremediation a time-consuming process. To resolve this problem the researchers would just like to experiment on possibility of using mine tailings as alternative in growing ornamental plants for future use in phytoremediation. Among the ornamental plants the researchers chosen petunia because of the following characteristics and reasons: Petunias are popular and reliable flowering ornamental plants. Versatile annuals, petunias can be used in flower beds, hanging baskets, window boxes and other types of containers. They also can be used as cut flowers. The blossoms of petunias come in many colors with petal edges that are straight or ruffled. Two general classes of petunias are *Grandiflora and Multiflora. Grandiflora* petunias are characterized by having fewer, but larger, showy flowers. A number of Grandifloras are cascade selections, well suited to growing in hanging baskets, window boxes and other types of planters. Multiflora petunias have a more compact growth habit and have smaller but more numerous blossoms. Multifloras generally withstand wind and hard rains better than the types may have single flowers with one set of petals on each flower, or double flowers with multiple sets on of petals each flower. Petunias are normally propagated from seed but maybe grown from seedlings. Seed is best sown indoors four to six weeks prior to planting outdoors. Commercially prepared mixes work best to germinate seed.

Seedlings can emerge in three to four days under optimum conditions small seedling .The young seedlings can be fertilized with a diluted formulation of starter fertilizer. The seedlings can be transplanted to trays or individual containers at the two leaf stage, or in about 14 to 21 days.

Petunia is a widely-cultivated genus of flowering plants of South American origin, closely related with tobacco, cape gooseberries, tomatoes, deadly nightshades, potatoes and chili peppers; in the family Solanaceae. The popular flower derived its name from French, which took the word *petun*, meaning "tobacco," from a Tupi-Guarani language. Most of the varieties seen in gardens are hybrids (*Petunia × hybrid).*

According to Deborah Brown (Extension Horticulturist) *Department of Horticultural Science* Petunias require little to no maintenance. Deadheading is only necessary when encouraging the plants to become bushier. Petunias tolerate a range of soil pH and they don't like to be dry for long periods, but they also don't like wet feet.

In this study, the dependent variables that were investigated are the germination and growth of Petunia seeds as to the number of seeds germinated, number of leaves produced, length of seedlings and length of primary roots which are measured at the end of this study or the result of this study.

The independent variables are different percentages of fertile soils and mine tailings without organic fertilizer and with organic fertilizer that serve as the bases or criteria of this study.

This study aimed to evaluate the effects of mine tailings on the numbers of seed germinated, number of leaves, length of seedlings and length

Grandifloras. Both Grandiflora and Multiflora of primary roots; assess the effects of the various percentages of mine tailings; determine the interaction effect of the various percentages of mine tailings with fertile soil and organic fertilizers; and establish the best kind of soil and mine tailing ratios on the germination of seeds and growth of seedlings.

II. METHODOLOGY

The study was conducted in home garden situation at Pacdal, Baguio City, Philippines from August to September 2010. The mine tailings were obtained from private mine abandoned for six months. The name of the private mine was not specified for confidentiality. Experimentation was performed to determine the germination and growth of petunia seeds. Selections of plant candidate from varieties of seeds were considered. The ideal candidate is petunia seeds since it can sprout at a minimum period of seven days.

The following preparations were made by the researchers for the first set of triplicates without organic fertilizer.

100% Fertile Soil - 350g Fertile Soil
25% Mine Tailing - 87.5g Mine tailing and 262.5g Fertile Soil
50% Mine Tailing = 175g Mine tailing and 175g Fertile Soil
75% Mine Tailing = 262.5g Mine tailing and 87.5g Fertile Soil
100% Mine Tailing = 350g Mine Tailing

For the second set of triplicates organic fertilizer was added.

100% Fertile Soil = 350g Fertile Soiland 2 teaspoons of organic fertilizer

5% Mine Tailing = 87.5g Mine tailing and 262.5g Fertile Soil and 2 teaspoons of organic fertilizer

50% Mine Tailing = 175g Mine tailing and 175g Fertile Soil and 2 teaspoons of organic fertilizer

75% Mine Tailing = 262.5g Mine tailing and 87.5g Fertile Soil and 2 teaspoons of organic fertilizer

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100% Mine Tailing = 350g Mine Tailing and 2 teaspoons of organic fertilizer

Fertilizer Application

After one week of sowing the petunia seeds, two teaspoons of organic fertilizer ($12N$-$10P_2O_5$-$10K_2O$) was dissolved in one cup of water and was thoroughly used to water the plants. All treatment containers received a common dose of the organic fertilizer seven days after planting.

Distilled water was added and mixed thoroughly to the treatment containers with fertile soil and different percentages. The pH of the fertile soil and different percentages of mine tailings were determined using the pH meter:

Fertile soil = pH 5.9
25% mine tailings = pH 5.2
50% mine tailings = pH 4.3
75% mine tailings = pH 4.0
100% mine tailings = pH 3.4

The experimental method of research was used in this study since it involved description, recording, analysis and interpretation of data gathered from experimental procedure in order to solve problem. It was also comparative because the percentages of mine tailings were compared according to its effect on the germination of petunia seeds, number of leaves, length of seedlings and length of primary roots produced.To determine if there is a significant difference in the number of seeds germinated, number of leaves, length of seedlings and length of primary roots produced. One-Way Analysis of Variance (ANOVA) was used since this statistical technique is used to compare the means of more than two variables. In this study, pure fertile soil and different percentages of mine tailings without and with organic fertilizer were compared

III. RESULTS AND DISCUSSION

This chapter presents, analyzes and interpreted the following: the effect of the pure fertile soil and the fertile soil mixed with the different percentages of mine tailings to the number of seeds germinated, number of leaves, length of seedling, and length of primary roots; the different in the effect of mine tailings with organic fertilizer and without organic fertilizer as to the number of seeds germinated, number of leaves, length of seedlings, and length of primary roots.

Effect of soil-mine tailings in seed germination

The study observed how pure soil and soil with mine tailings additives affect plant growth. There are several growth indicators used in the study. These include number of seed germinated, number of leaves, length of Seedlings and length of primary roots. Results divulged that each media concentration has specific effect as indicated by the varying results indicated by these parameters.

Table 1 shows the relationship of pure fertile soil as well as those with mine tailing additives and germination. It reflects that there is an inverse relationship of germination and the mine tailing concentration. The higher the amount of mine tailings added, the least the number of germinated seeds.

Effects of the concentrations of mine tailings vary significantly among each treatment as indicated by the statistical findings (Fcv = 115.833, with significant level of 0.000). No germination occur in pure mine tailings and a very limited rate in a 75% mine tailing media.

The findings signified that amount of soil and mine tailings have a significant effect on the rate of germination. Plant germination seemingly are restricted in mine tailings may due to the presence of different minerals particularly heavy metals, which usually in high concentration cause unfavorable growing conditions to seeds.

Effect of fertilizer in seed germination in a mine tailing media

Table 2 on the other hand, reflects the influence of fertilizer on the rate of germination. Finding showed that fertilizer somewhat enhanced germination as indicated by the higher mean (than with that of Table 1 or with no fertilizer). Interestingly, the table shows that addition of fertilizer boosts germination rate even in soils mixed with mine tailings.

It was found out that in 25% and 50% mine tailings media, there is a relatively high number of seeds that germinated (with an average of 9.67 and 9.33, respectively). However, statistical finding shows that germination in 50% mine tailing is significantly lower than in pure soil (Fcv 167.333 with 0.000 significant) but do not significantly differ with that of the 25% mine tailing. It implies that it is not as conducive as pure soil. Further, 75% mine tailing has a significantly lower rate (4.00) than pure soil (11.33), 25% mine tailing (9.67) and 50% mine tailing (9.33). This connotes that the effect of fertilizer in conditioning the media also is proportional to the amount of tailings. On one hand, in pure mine tailing media there was no germination that occur. It implies that the fertilizer is not enough to condition the soil and allow seed germination. Nonetheless, it was found out that there is somewhat a significant effect of fertilizer in enhancing seed germination in soil and tailings media as indicated by the higher rate of germination as compared to that with no fertilizer added.

Soil-mine tailings effect on leaves development

Table 3 presents the effect of soil and mine tailing concentrations on the number of leaves. It shows that mine tailing at 75%, 50% and 25% concentration significantly affect the number of leaves. The table shows that leaves development in media with these tailings concentrations are significantly restricted. The rate of leaves development among these concentrations (an average of 2.67, 2, and 2 for 25%, 50% and 75%, respectively) are significantly lower than that of the pure soil (4.0) as reflected in the statistical interpretation (Fcv= 23.500 with 0.000 level of significance). However, data shows that effect of 25% mine tailing do not significantly vary to that of the pure soil. Clearly, the findings proved that further development of plant organs are affected or are influenced by soil minerals concentrations. In this case, it suggests that mine tailings at any rate will affect leave formation.

Soil-mine tailing and fertilizer effect on leaves development

Table 4, in contrast shows leaves development in soil and mine tailings with fertilizers. Findings points that there is a consistent effect of mine tailing concentrations in leaves development with or without fertilizers. The table showed significantly the same result with that of table 3. Leaves in a pure soil with fertilizer (4.67) do not significantly differ with that of the 25% mine tailings (4.33). Interestingly, the other concentrations (50% and 75%) have almost the same number of leaves (2.33 and 2.00, respectively). Further, the table signified that growth is totally prohibited in pure mine tailings. The table points that adding fertilizer to pure soil and mine tailing media do not results to a significant difference in the number of leaves produced. It follows with that of the non-fertilized media.

Effect of mine tailings and fertilizer in seedling length

One of the indicators in assessing the effect of mine tailings in plant development is seedling length. This was presented in Table 5. Finding shows that there is a clear confirmation that plant development will be significantly affected at a relatively higher tailing concentration (about 50%). This was affirmed by the statistical finding, wherein, seedling length at 25% mine tailing concentration(26 mm) do not significantly differ with that of pure soil (28.33 mm). The same table showed that length of seedlings at 50% and 75%, 14.67 mm and 6 mm, respectively, are significantly shorter than the two former lengths. The statistic also reflect that seedling length at 50% mine tailings is significantly longer than that of the 75% mine tailings.

Table 6 on the other hand presents the effect of fertilizer on the length of seedlings. Generally, fertilizers seem to boost length. This data is evident in the higher length than that of those with no fertilizers. The effect of fertilizer to the length of seedlings in the mine tailing media is still consistent with the development pattern in pure soil. Findings showed that seedling length at 25% mine tailings (36.67 mm) is significantly shorter than of the pure soil (39.67 mm). But, these two are significantly different with 50% mine tailings (31 mm) and 75% mine tailings (17.67 mm). On the other hand, 50% mine tailing can allow better seedling lengths than 75% mine tailings. In general, the table contests that there is almost absolutely significant difference among the treatments as indicated by the Fcv of 999.375, with significance level of 0.000 ($P<0.000$).

Soil, Mine tailings and Fertilizer effect on primary root length

The study also delved in identifying the effect of mine tailings in primary root development. The data were presented in table 7. Generally, the table depicts that there is a significant effect of mine tailing concentration in primary root growth. Finding shows that primary roots in the 25%, 50% and 75% mine tailings media (with 2.67, 1.00 and 1.00 mean, respectively) are significantly lower than of the pure soil media (4.00). This affirmation was signified by the statistical findings where there is a highly significant level or about zero percent error (Fcv = 113.500 with Significant level of 0.000).On the other, the table shows that 50% (mean = 1 mm) and 75% (mean = 1 mm) mine tailings are significantly incapable to promote root growth than pure soil (4 mm) and 25% (2.67 mm) mine tailings. The data reveal that addition of more mine tailings hinders growth and development of roots.

On one hand, effect of fertilizer on primary root growth was elaborated on table 8. It reflects that addition of fertilizer to the media increased its ability to support root development. Addition of fertilizer resulted to a significant increase in the root length. Comparing to the non-fertilized media, roots of the plant grown in 25% mine tailing is much longer (3.33 mm), so as with that of the 50% and 75% mine tailings (with mean lengths of 2.67 mm and 2.33 mm). There are significant increases of the root lengths upon application of fertilizer. However, the same principle as in the non-fertilized media is observed. Generally, there is a declining trend of root length as the amount of tailings is increased. The average root length of 3.33 mm, 2.67 mm and 2.33 mm (for 25%, 50% and 75% mine tailings, respectively, are significantly lower than of the pure fertilized soil. This was confirmed with the statistical findings where there a significantly very low percentage error (Fcv = 16.389 with 0.000 significance level). This is depicts a consistent findings with that of the non-fertilized soil media, wherein, addition of mine tailings will hinder normal root growth.

Table 1. Effect of pure and mixed soil-mine tailings media on seed germination

Without Fertilizer	R1	R2	R3	Mean
100% Natural Soil	10 seedlings	10 seedlings	9 seedlings	9.67a
25% Mine Tailing	7 seedlings	6 seedlings	7 seedlings	6.67b
50% Mine tailing	5 seedlings	3 seedlings	4 seedlings	4.00c
75% Mine Tailing	1 seedlings	1 Seedlings	2 seedlings	1.33d
100% Mine tailing	0 seedlings	0 seedlings	0 seedlings	0.00e
Fcv = 115.833 – Significant ; Sig. Level = 0.000				

(Note: Means with different letters significantly differ at $P_{(0.01)}$)

Table 2. Effect of fertilized pure soil and mixed soil-mine tailings media on seed germination

With Fertilizer	R1	R2	R3	Mean
100% Fertilized Soil	11 seedlings	12 seedlings	11 seedlings	11.33a
25% Mine Tailing	10 seedlings	10 seedlings	9 seedlings	9.67ab

50% Mine tailing	9 seedlings	9 seedlings	10 seedlings	9.33b
75% Mine Tailing	3 seedlings	5 Seedlings	4 seedlings	4.00c
100% Mine tailing	0 seedlings	0 seedlings	0 seedlings	0.00d
Fcv = 167.333 – Significant ; Sig. Level = 0.000				

(Note: Means with different letters significantly differ at $P_{(0.01)}$)

Table 3. Effect of pure and mixed soil-mine tailings media on number of leaves

Without Fertilizer	R1	R2	R3	Mean
100% Fertile Soil	4 leaves	4 leaves	4 leaves	4a
25% Mine Tailing	2 leaves	4 leaves	2 leaves	2.67 ab
50% Mine tailing	2 leaves	2 leaves	2 leaves	2b
75% Mine Tailing	2 leaves	2 leaves	2 leaves	2b
100% Mine tailing	0 leaves	0 leaves	0 leaves	0c
Fcv = 23.500 – significant ; Sig. Level = 0.000				

(Note: Means with different letters significantly differ at $P_{(0.01)}$)

Table 4. Effect of fertilized soil and mixed soil-mine tailings media on number of leaves

With Fertilizer	R1	R2	R3	Mean
100% Fertile Soil	5 leaves	5 leaves	4 leaves	4.67ab
25% Mine Tailing	4 leaves	5 leaves	4 leaves	4.33ab
50% Mine tailing	2 leaves	3 leaves	2 leaves	2.33b
75% Mine Tailing	2 leaves	2 leaves	2 leaves	2c
100% Mine tailing	0 leaves	0 leaves	0 leaves	0d
Fcv = 54.167 – significant ; Sig. Level = 0.000				

(Note: Means with different letters significantly differ at $P_{(0.01)}$)

Table 5. Effect of pure and mixed soil-mine tailings media on length of seedlings(mm)

Without Fertilizer	R1	R2	R3	Mean
100% Fertile Soil	29	27	29	28.33a
25% Mine Tailing	27	25	26	26.00a
50% Mine tailing	15	13	16	14.67b
75% Mine Tailing	6	6	6	6.00c
100% Mine tailing	0	0	0	0.00d
Fcv = 486.071 – significant ; Sig. Level = 0.000				

(Note: Means with different letters significantly differ at $P_{(0.01)}$)

Table 6. Effect of fertilized soil and mixed soil-mine tailings media on length of seedlings(mm)

With Fertilizer	R1	R2	R3	Mean
100% Fertile Soil	40	39	40	39.67a
25% Mine Tailing	37	37	36	36.67b
50% Mine tailing	31	32	30	31.00c
75% Mine Tailing	18	16	19	17.67d
100% Mine tailing	0	0	0	0.00e
Fcv = 999.375 – Significant ; Sig. Level = 0.000				

(Note: Means with different letters significantly differ at $P_{(0.01)}$)

Table 7. Effect of pure and mixed soil-mine tailings media on length of primary roots(mm)

Without Fertilizer	R1	R2	R3	Mean
100% Fertile Soil	4	4	4	4.00a
25% Mine Tailing	3	2	3	2.67b
50% Mine tailing	1	1	1	1.00c
75% Mine Tailing	1	1	1	1.00c
100% Mine tailing	0	0	0	0.00d
Fcv = 113.500 – significant ; Sig. Level = 0.000				

(Note: Means with different letters significantly differ at $P_{(0.01)}$)

Table 8. Effect of fertilized soil and mixed soil-mine tailings media on length of primary roots(mm)

With Fertilizer	R1	R2	R3	Mean
100% Fertile Soil	5	6	4	5.00a
25% Mine Tailing	4	4	2	3.33ab
50% Mine tailing	2	3	3	2.67ab
75% Mine Tailing	2	2	3	2.33b
100% Mine tailing	0	0	0	0.00d
Fcv = 16.389 – Significant ; Sig Level = 0.000				

(Note: Means with different letters significantly differ at $P_{(0.01)}$)

IV. CONCLUSION AND RECOMMENDATION

The higher the amount of mine tailings added, the least the number of germinated seeds. Plant germination seemingly are restricted in mine tailings may due to the presence of different minerals particularly heavy metals, which usually in high concentration cause unfavorable growing conditions to seeds.

The findings proved that further development of plant organs are affected or are influenced by soil minerals concentrations. In this case, it suggests that mine tailings at any rate will affect leaves formation.

It was found out that there is somewhat a significant effect of fertilizer in enhancing seed germination in soil and tailings media as indicated by the higher rate of germination as compared to that with no fertilizer added.

The adding of fertilizer to pure soil and mine tailing media do not show a significant difference in the number of leaves produced.

It reflects that addition of fertilizer to the media increased its ability to support root development. Addition of fertilizer resulted to a significant increase in the root length.

Based on the foregoing findings, the following proposals are offered:

There is a wide range of seeds which are salt and metal tolerant. Since the plant used in the study was limited to petunia only, attempts to discover other salt and metal tolerant flowering plant is suggested. Considering also the climate that the researchers sown the petunia seeds it is advised that other study must follow recommended season to obtain efficient results. It is advised that study or research similar to this be replicated considering other alternative soils such as biosolids or sludge from sewerage water treatment plant. An additive must be added to the mine tailings prior to planting to increase the pH of the acidic soil. A study on the different ages of mine tailings is also recommended. It is recommended that a further study on the effect of fertilizers with higher concentrations on seed germination be performed to provide an idea on the proper amount needed to enhance seed germination of different ornamental seeds.

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