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Bioleaching of industrial waste foundry sand by *Aspergillus* sp. treated as biofertilizer for the growth of herbal plants - *Coriandrum sativum*

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ABSTRACT

The present work aims to investigate the potential of Aspergillus sp. in the bioleaching of waste foundry sand and to support the growth of Coriandrum sativum. The WFSs were from aluminum, iron and steel foundries. This study also assesses the availability of Al, Cd, Co, Cu, Fe, Mg, Ni, Pb, and Zn in WFS. Although there were differences in the amounts of metals accumulated by the various plant species, excessive amounts of heavy metals were not taken up, regardless of WFS treatment. Hence, our study is designed to bioleach the metals present in waste foundry sand using Aspergillus sp. and to use it as a biofertilizer for the growth of Coriandrum sativum. The waste foundry sand was collected from different regions around Chennai and Coimbatore districts. The physical properties such as coloration like (black, and light black). Texture (Round and spherical), Moisture (0.75, 0.97), temperature (Room Temperature), solubility (dissolved and settled) and pH were measured (5-9) using standard protocols. The chemical properties of treated and untreated waste foundry sand were observed. The analyzed shows increase level of aluminum and iron and decreased levels of Copper and Zinc in waste foundry sand. The waste foundry sand was bioleached using Aspergillus sp. The treated and untreated sand was later used for growing Coriander sapling under controlled conditions and observed for the metal absorption after growth. Our observations provide supportive document on bioleaching of WFS by Aspergillus sp. was adequate in the growth of herbal plant Coriandrum sativum.

Keywords: *Foundry sand, bioleaching, Coriandrum, heavy metals.*

1. INTRODUCTION

Foundry sand is high quality silica sand that is used to make mold for ferrous and nonferrous metal casting. Foundry sand consists of uniformly sized, high-quality silica sand that is bonded to form molds for ferrous (iron and steel) and nonferrous (copper, aluminum, brass) metal castings. The recycled sand degrades such that it cannot be reused in the casting process. The sand could not be reused and hence removed from the foundry and is termed as waste foundry sand. The automotive industry and its supplier of parts are the major generators of foundry sand (Rafat siddique *et al.,* 2010).

Bioleaching is defined as an interaction between microorganisms and metals that causes the solubilization of metal, and is based its ability to transform solid compounds, thus resulting in soluble and extractable elements (Brandl *et al*., 1997). Schinner and Burgstaller (1989) suggested that bioleaching mainly includes three groups of microorganisms: autotrophic bacteria, heterotrophic bacteria and fungi. The most effective bioleaching bacteria are *Acidithiobacillu* and fungi, *Aspergillus* and *Penicillium* (Krebs *et al*., 1997).

The purpose of this study was to characterize the metals (Fe, Pb, Zn, Mg, silica, Al, Cu) in waste molding sands from ferrous and non-ferrous foundries and the relationship of soil microbial toxicity of the WFS. The Aspergillus sp was isolated from wasted foundry sand and is harvested in the laboratory and used for bioleaching process.. Physical and chemical properties were analyzed (SITRA and Matex lab). Treated and untreated WFS by using Coriander (*Coriandrum sativum*) plant.grown on waste foundry sand from aluminum, iron and steel foundries using plant to assess the availability of metals in waste foundry sand is an important step in analyzing the environmental risks of these materials before they are beneficially used in manufactured soil.

2. MATERIALS AND METHODS

COLLECTION OF SAMPLES

The waste foundry sand was collected from different area around Chennai and Coimbatore districts.

PHYSICAL PROPERTIES OF SOIL SAMPLE

The physical properties of WFS such as particle gradation, fine contents, density, moisture, temperature, absorption and specific gravity help to recognize its workability and suitability. Were identified based on the protocol followed from Carey and Sturtz 1995. The results were shown in table 1.

CHEMICAL PROPERTIES OF SOIL SAMPLE

Chemical composition of the waste foundry sand depends on the type of metal, type of binder and combustible used. The chemical composition of the foundry sand may influence its performance. Waste foundry sand is rich in silica content. Silica sand is hydrophilic and consequently attracts water to its surface. Chemical composition of WFS was reported by American Foundry men's Society (1991), Guney *et al.* (2010), Etxeberria *et al*. (2010), and Siddique *et al.* (2011). The results are show on table 2.

PROCESSING OF THE SAMPLE

About one gram of sand sample was dissolved in 100 ml of distilled water, and vigorously shaken for two minutes. Then the suspension were serially diluted from 10^{-2} to 10^{-6} and it was plated on potato dextrose agar (PDA), Rose bengal agar medium by using spread plate method and incubated at 37º C for 24 hours.

MORPHOLOGICAL CHARACTERISTICS

Cultures were identified on the basis of colony morphology, color, texture, appearance and growth pattern of colonies on Rose bengal agar and PDA (HiMedia Labs, India).

BIOCHEMICAL TEST

The selected strains were subjected to biochemical tests such as indole, MR-VP, catalase, TSI, citrate using high medium (Cappuccino, 1992). The carbohydrate fermentation medium was prepared with 1% concentration of glucose, lactose and maltose by using bromothymol blue as indicator and dispensed in tubes with inverted Durham's tubes. The results were given in table3.

TREATMENT OF WASTE FOUNDRY SAND USING MICROORGANISMS

Waste foundry sand was spread in plastic tray in layers. Broth cultures of *Aspergillus sp.*, was prepared. For this, 1cm thick layer of Waste foundry sand was made as bottom layer and it was drenched with water. Middle layer of waste foundry sand was sprayed with broth culture. These plastic trays were then placed at room temperature for 28^0C for 30 days. After 30 days, the samples were considered as treated foundry sand and is used for cultivating plants. The chemical properties of treated and untreated WFS were done in SITRA Labs, Coimbatore and Matex Lab, Chennai.

SELECTION OF PLANT

Coriander (*Coriandrum sativum)* native to regions from southern Europe and northern Africa to Southwestern Asia. It is a soft plant growing to 50cm (20 in) tall. Leaves are particularly rich in vitamin A, vitamin C and vitamin K, with moderate content of dietary minerals. Although seeds generally have lower content of vitamins, they do provide significant amount of fiber, calcium, selenium, iron, magnesium and manganese.

PLANT GROWING CONDITIONS

Each plastic pot (15 cm and dia.) was filled with 1.500kg of the foundry sand blend. The drainage holes were covered with nylon mesh to help retain the sand in the pots. There were four replicates of each treatment and untreatment, plus the control. Water was added to the pots 48 h before sowing to thoroughly wet the sand. Pots were sown with, the coriander seedlings were thinned to three pot. The pots were kept in a growth chamber, and under a light-dark cycle.

3. RESULTS AND DISCUSSION

PHYSICAL CHARACTERISTICS:

Table 1: physical properties of waste foundry sand

	Sand 1	**Sand 2**
Color	Black	Black
pH	7.50	6.72
Texture	Round	Spherical
Temperature	RT	RT
Moisture	0.97	0.95

Solubility	Settled	Settled

The WFS colors are observed black color, the pH (7.50-6.72), Texture (Round and Spherical), Temperature (RT), Moisture (0.97-0.95), Solubility (settled).

CHEMICAL CHARACTERISTICS

Table 2: chemical properties of waste foundry sand

Metals	**Untreated**	**Treated**
Silica	155	92.10
Copper	30.2	18.5
Lead	25.45	DL* (0.1)
Iron	80.16	46.79
Zinc	37.5	17.4
Cadmium	107	DL (0.1mg)
Aluminum	2295	1728
Magnesium	612	557
Potassium	852	131

*Dl- Detected limit

The chemical properties of WFS's metals are observed as follows: silica present in untreated sand was 50.5% and in treated sand 0.92%, copper present in untreated sand was 0.30% and in treated sand 0.18%, lead present in untreated sand was 0.25% and untreated sand 0.001%, Iron present in untreated sand was 0.80% and treated sand 0.467%, Zinc present in untreated sand was 0.375% and in the treated sand 0.017%, cadmium present in untreated sand was 1.07% and treated sand 0.001%, aluminum present in untreated sand was 22.95% and in treated sand 17.28%, magnesium present in untreated sand was 6.12% and treated sand 5.57% and potassium present in untreated sand was 8.52% and in treated sand 1.31%. Hence there was a difference in treated and untreated WFS in the presence of concentration of metals.

MORPHOLOGICAL CHARACTERISTICS

MACROSCOPIC OBSERVATION

The growth on potato dextrose agar showed cottony with white, yellow or green color, covered with black spores.

MICROSCOPIC OBSERVATION

On microscopic observation, the hyphae was wide septate with acute angle branching, tree or fan like branching. Conidial head biseriate, radiate conidia in chain or dispersed.

BIO CHEMICAL TEST

Table.3 shows the results of biochemical analysis

Bio chemical	**Aspergillus niger**
Indole	Negative
Methyl red	Negative
Citrate	Positive
Catalase	Negative
TSI	Alkaline/acid
Glucose	Positive
Lactose	Positive
Sucrose	Negative
Maltose	Positive

The fungi from morphological and biochemical analysis was identified to be *Aspergillus niger* according to Guney *et al*., 2010.

ANALYSIS OF WASTE FOUNDRY SAND IN HERBAL PLANT UNDER CONTROLLED CONDITIONS

The plant coriandrum was grown on treated, untreated and control sand (fertile soil). It was observed that the length, fast growth, size of the leaves of coriander plants were increased in control and treated 20 cm (bioleached) waste foundry sand than the untreated waste foundry sand (12cm). The healthy plants were harvested from both treated and control pots (Fig.1).

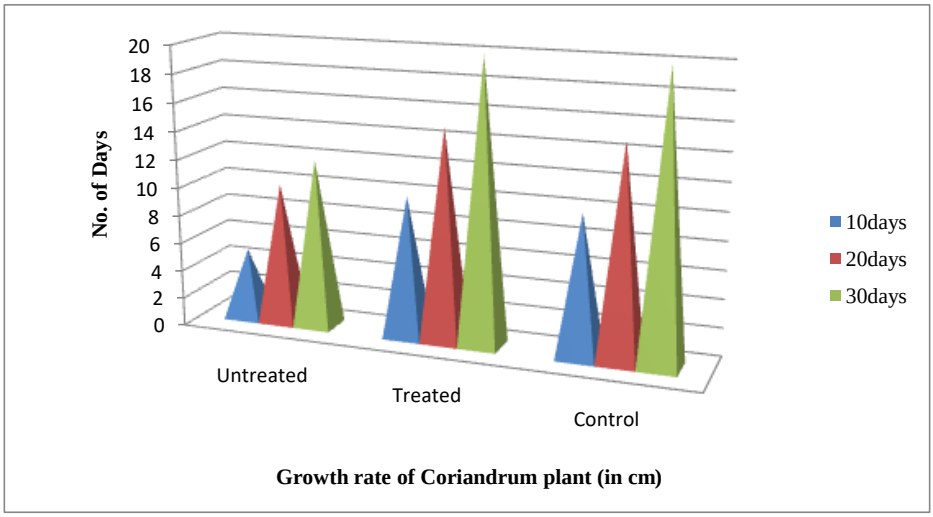

Fig 1: Analysis of growth rate of *Coriandrum sativum* in WFS

4. SUMMARY AND CONCLUSION

Foundry sand are used to make mold and cores. The waste generated from the industries cause environmental pollution and hence, the reuse of this waste material can be emphasized. Foundry sand is a high quality silica sand that is a byproduct from the production of both ferrous and nonferrous metal casting industries. Waste foundry sand in this study was a by-product of metal foundries which contained heavy metals like Cd, Cr, Pb, Hg, Li and other toxic substances. Moisture content was found to be observed from 6.4-9.0. The pH of waste foundry sand was 6.5-7.5. WFS contained high silica content (50.5%). The samples were detected for the presence of metal degrading fungi, *Aspergillus niger*. The *Coriandrum sativum* sapling grew well under controlled conditions in bioleached WFS and then in untreated sand. The metal absorption values for treated sand shows a drop in the levels of metals present in treated foundry sand than in untreated sand. Hence, the metal degrading ability of *Aspergillus* sp. helps in converting useless WFS sand to fertile soil rich to grow seeds or saplings. Our observations provide supportive document on bioleaching of WFS by *Aspergillus* sp. was adequate in the growth of *Coriandrum sativum*.

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