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RESEARCH ARTICLE

MICROBIAL DEGRADATION OF WASTE FOUNDRY SAND

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ABSTRACT

Waste foundry sand (WFS) represent the highest amount of solid wastes generated by foundries.WFS is a by-product of ferrous and non-ferrous metal casting industries .Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry and it is termed as waste foundry sand. Indian foundry industry is the 4th largest casting producer in the world. The majority (95%) of the foundry units in India falls under the category of small scale industry. These foundries generates approximately 17, 10000 tones WFS/year. Microbial research and the need for new methods for the removal of heavy metals and other contaminants led to the great deal of expansion in the field of biological methods of industrial waste clean-up. This study aimed to present the utilization of microorganisms treated WFS in Horticulture. This experimental investigation was performed to evaluate the properties of treated and untreated WFS and the sand was partially replaced with WFS. Physical and chemical properties analyzed between treated and untreated WFS. In Horticulture instead or with sand the treated sand WFS can be used.

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INTRODUCTION

Foundries around the world use vast quantities of sand to make metal casting moulds and cores (used to make cavities in moulds). A foundry is a manufacturing facility that produces metal casting by pouring molten metal into a performed mould to yield the resulting hardened cast. The primary metal cast includes iron and steel from the ferrous family and aluminium copper, brass and bronze from the nonferrous family Waste foundry sand (WFS) consists primarily of, uniformly sized, high-quality silica sand or lake sand that is bonded to form moulds for ferrous (iron and steel) and nonferrous (copper, aluminium, brass) metal castings. Foundries use high-quality size specific silica sands for use in their moulding and casting operations. The raw sand is normally of a higher quality than the typical bank run or natural sands used in fill construction sites. In the casting process, moulding sands are recycled and reused multiple times. Eventually, however, the recycled sand degrades to the point that it can no longer be reused in the casting process. When it is not possible to further reuse in the foundry it is removed from the foundry and termed as waste foundry sand.

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The automotive industry and its parts suppliers are the major generators of foundry sand. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. Beneficial use of WFSs preserves natural resources by decreasing the demand for virgin materials, conserves energy and reduces greenhouse gas emissions through reduced mining activities, and decreases the economic and environmental burdens of disposal.

The leachate obtained from such materials may contain hazardous compounds, which may possibly affect the environment. So it is important to know the characteristics of leachate obtained from waste foundry sand. In the casting process, moulding sands are recycled and reused multiple times. Eventually, however, the recycled sand degrades to the point that it can no longer be reused in the casting process. When it is not possible to further reuse in the foundry it is removed from the foundry and termed as waste foundry sand. The automotive industry and its parts suppliers are the major generators of foundry sand. Bioleaching is a process described as "the dissolution of metals from their mineral source by certain naturally occurring microorganisms" or "the use of microorganisms to transform elements so that the elements can be extracted from a material when water is filtered through it".

The function of the microbes in the bioleaching process was more clearly defined only form the 1950s; however Briefly (1990) and Brombacher *et al.* (1997) demonstrated the bacterial catalysis of iron oxidation and sulphuric acid formation in mine waters. The application of bioleaching form mining ores to industrial wastes, as increasingly vast quantities of hazardous industrial waste (e.g. fly ash, waste foundry sand, slag and filter dust etc.) are produced worldwide. Initially, the main focus of bioleaching was the recovery of metals from insoluble metal sulphide minerals in mining ores. It was based on the ability of microorganisms to oxidize reduced iron and sulphur compounds. Brombacher *et al.* (1997) suggested the removal of metals form these industrial wastes brings about a detoxification of the residues and thus improves environmental quality.

Bioaccumulation can be another important mechanism in fungal bioleaching (Burgstaller and Schinner, 1993). In the accumulation process, the mycelium functions as a "sink" for the metal ions. The accumulation of metal ions from the leaching solution through active metabolic reactions and passive adsorption upsets the equilibrium between the solid and dissolved metal, thus causing the continuous solubilisation of the metal. The fungal cell wall contains many different functional groups (e.g. hydroxyl, amine, carboxyl, phosphate and sulphydrl groups), which are able to bind metal ions to a greater or lesser extent (Kapoor and Viraraghavan, 1995).Among the filamentous fungi, the genera of *Aspergillus* and *Penicillium* have been reported to have a high ability to accumulate heavy metals from their external environment (Volesky, 1991).Burgstaller and Schinner (1993a) isolated and used the most active leaching fungi which belong to the genera *Penicillium* or *Aspergillus.* They reported *Aspergillus niger* and *Penicillium simplicissimum* to be the most important species because of their ability to excrete abundant amounts of organic acids for solubilisation of metal compounds such as oxides, carbonates, silicates and hydroxides. A sucrose and mineral salts medium was initially used to produce citric and gluconic acids by *A. niger* at various concentrations of tailings (1, 5, 7, 10 and 15% w/v). Maximal removal of up to 60% of the copper was obtained for the 5% tailings when the organic acid supernatant was added to the tailings. In a single step process, *A. niger* was then grown in the presence of mining tailings at various concentrations.

Maximum copper solubilisation (63%) occurred with 10% mining tailings using sucrose as the substrate. Other substrates were then evaluated including molasses, corn cobs and brewery waste (10% mining tailings). Sucrose gave the best results for copper removal, followed by molasses, corn cobs and brewery waste.This experimental investigation was performed to evaluate the WFS properties .WFS was treated with an isolated fungal strain .Physical and chemical properties analyzed between fungal treated and untreated WFS. In horticulture, the treated WFS were replaced instead of sand and the plants were grown.

MATERIALS AND METHODS

Glasswares

All the glass wares viz., petri plates, conical flasks, test tube were taken, The glass wares were kept for 24 hours in cleaning solution which consists of potassium dichromate and 60 ml of concentrated sulphuric acid in one liter of water. They were then washed with tap water and later rinsed with distilled water and dried .All these glass wares were then sterilized in hot air oven at 160 ° C for 2 hours.

Collection of samples

The WFS was collected from different area around Coimbatore district.

Physical properties of soil sample

The physical properties of the collected WFS sample were studied. The physical properties such as colour, texture, solubility, moisture, pH, temperature, were done.

Moisture: Moisture content of the collected sand sample was calculated by using following formula,

Moisture, percent = A/B * 100
Where,

A = Loss of weight of the sand sample in gram on heating.
B = Weight in gram of the sand sample taken.

pH: pH is the negative log of the activity of the hydrogen ion concentration.

Temperature: Temperature of the collected sand sample was varying with environmental conditions.

Chemical properties of soil sample

The chemical properties of WFS were done in SITRA, Coimbatore.

Isolation of Fungi

Plating technique

About one gram of foundry sand was added to 99ml of sterile distilled water in a conical flask. The content was shaken vigorously. About 1 ml was serially diluted up to 10-3 to 10-5 for fungi and 0.1 ml was placed on a Rose Bengal agar by using spread plate method. Then the plates were incubated at room temperature for 3-4 days.

Microscopic observation

Lacto phenol cotton blue mount

Lacto phenol cotton blue stains the fungal cytoplasm and provides a light blue background against which the wall of hyphae can readily been seen, to visualize the morphological features of the fungal cultures. A drop of lacto phenol cotton blue was kept on a clean slide. A small tuft of fungal mycelium with spores and spore bearing structures were placed into the drop and gently teared to expose all parts evenly.

Table 1. The location, colour, pH, texture and moisture content of WFS

Sample	Latitude	Color	pH	solubility	Texture	Moisture
FS1	11.1126°N	Black	7.89	Light Dissolved	Sub-angular	0.98
FS2	11.0316°N	Grey	5.03	Dissolved	Round	0.97
FS3	11.0900°N	Light black	9.9	Light brownish dissolved	Spherical	0.91
FS4	11.3000°N	Black	9.10	Settled	Spherical	0.92
FS5	10.0785°N	Black	7.50	Light dissolved	Spherical	0.95
FS6	11.0842°N	Black	6.72	Light Dissolved	Round	0.96
FS7	11.0791°N	Black	8.70	Light dissolved	Round	0.94
FS8	10.7857°N	Black	8.00	Light dissolved	Sub-angular	0.93
FS9	11.0393 °N	Black	9.89	Settled	Sub-angular	0.97
FS10	10.9018°N	Black	4.39	Light dissolved	Sub-angular	0.92
FS11	11.0270°N	Black	8.7	Settled	Sub-angular	0.93
FS12	10.7857°N	Black	8.0	Dissolved	Spherical	0.96
FS13	11.0189°N	Black	9.89	Dissolved	Spherical	0.91
FS14	10.7888°N	Grey	4.39	Dissolved	Spherical	0.93
FS15	11.0366°N	Grey	5.49	Light dissolved	Spherical	0.93

A cover glass was placed, without air bubbles and observed for morphological features in bright field microscope.

Selective medium

Sabouraud's dextrose agar

The fungal isolates were picked with a sterile loop and inoculated on a sabouraud's dextrose agar medium and incubated at room temperature for 3-4 days.

Citric Acid Production Method

- Prepare the citric acid medium & dispense about 50ml in 250ml conical flask.
- Autoclave and allow it cool.
- Inoculate the medium with spores & incubate it on
- a shaker water bath at 25oC with gentle shaking for 3-5 days.
- After Incubation, filter the mycelium using double layered muslin cloth & measure the amount of citric acid in the filtrate by colorimetric and titrimetric methods.

Estimation Citric Acid by Titrimetric Method

The filtrate obtained is titrated against an alkali of known strength using phenolphthalein as indicator. The end point is the formation of pale pink colour. The volume of alkali used for neutralization is used to find the normality and the percentage of acid in the sample.

- 100ml of the filtrate is pipette into a conical flask and 2-3 drops
- of phenolphthalein indicator is added to it.
- This is titrated against 0.1N NaOH taken in the burette till a pale pink colour is
- Formed .
- The titration is repeated till concordant values are obtained.

Fungal Treatment Of WFS:

For Fungal treatment, WFS was spread in plastic tray in specific manner (layers) for proper spread of fungal mycelium. For this, 1 cm thick layer of WFS was made as bottom layer and it was drenched with water. Middle layer was consisting of baggage which served as the source of medium for the growth of fungus. Five days grown fungal culture was used inoculate WFS. After 30th days samples were taken out for reduction in metal analysis. The middle layer was covered by another layer of WFS. These plastic trays then placed at temperature of 28°C for 30 days. The chemical properties of treated WFS were done in SITRA, Coimbatore.

RESULTS AND DISCUSSION

Collection of WFS samples

The WFS sand was collected from 15 different areas around Coimbatore district.

Physical properties of soil sample

The physical properties of the collected WFS sample was studied .The physical properties such as colour , texture, solubility, moisture, p H was done. The result was tabulated in Table 1.

Chemical properties of untreated WFS

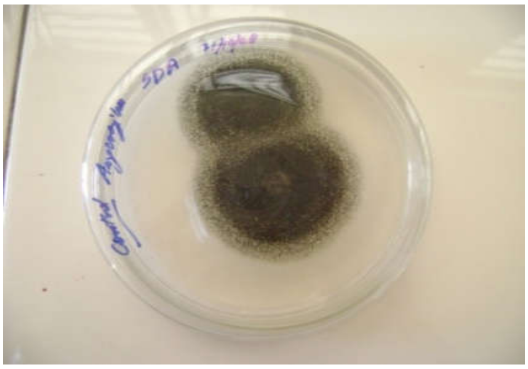
The chemical properties of untreated WFS were done in SITRA, Coimbatore.

S.No	Metals	mg/l
1.	Silica	1121
2.	Copper	201
3.	Lead	Not detected
4.	Iron	86364
5.	Zinc	596
6.	Calcium	33651
7.	Aluminium	Not detected
8.	Magnesium	28993
9.	Potassium	4739

Isolation of fungi

Macroscopic Observation

Fungal cultures were indentified on the basis of colony morphology, color, texture, elevation, appearance, and growth pattern of the fungal colonies obtained on a sabraouds dextrose agar. The FS1, FS5, FS 13 shows the *Aspergillus niger*. The result was shown in plate 1.



Microscopic Observation

Lacto phenol cotton blue mount

The identified isolates were mounted by lacto phenol cotton blue. It shows the *Aspergillus niger.*

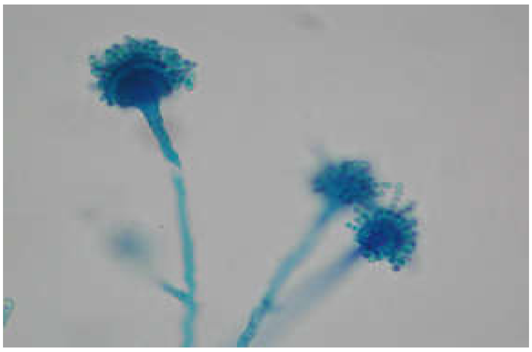


Fig. 1. Microscopic observation of *Aspergillus niger* under lacto phenol wet mount

Citric acid production method

The citric acid produced by *Aspergillus niger* was titrated against phenolpthalein as an indicator. The pale pink was produced was showed in Fig 2.

Fig. 2. Titration of citric acid using phenolphthalein produced by *Aspergillus niger*

Fungal Treatment of WFS

Five days grown fungal culture was used inoculate WFS. After 30th days samples were taken out for reduction in metal analysis. The middle layer was covered by another layer of WFS. These plastic trays then placed at temperature of 28°C for 30 days.

The chemical properties of treated WFS were done in SITRA, Coimbatore.

S.No	Metals	mg/l
1.	Silica	719
2.	Copper	130
3.	Lead	Not detected
4.	Iron	26542
5.	Zinc	184
6.	Calcium	27672
7.	Aluminium	Not detected
8.	Magnesium	14655
9.	Potassium	584

DISCUSSION

Foundry sand which is used to make mould and cores has been very important to foundry workers. The waste generated from the industries cause environmental problems hence, the reuse this waste material can be emphasized. Foundry sand is high quality silica sand that is a by-product from the production of both ferrous and nonferrous metal casting industries. Waste foundry sand is a by-product of metal foundries which contains many heavy metals (Cd, Cr, Pb, Hg, and Li) and other toxic substances. Moisture content was found to be observed as 6.4-9.0. The pH of waste foundry sand was 6.5-7.5. WFS contained high silica content (83.3%). Among 15 samples, three WFS samples were collected (FS1, FS5, FS 13). The samples were tested for Morphological and Biochemical characteristics to identify metal degrading organism. Based on morphological and organic acid production the isolated strains may be *Aspergillus niger.* Chemical analysis between treated and untreated WFS was done. In this parameter the chemicals present in WFS was degraded by *Aspergillus niger*. Further purification of enzymes in the organisms and technical methods can do to the identified isolates, which were co-cultured for the use of horticulture purpose.

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