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IMPACT OF MYCORRHIZAL FUNGI IN SOILS POLLUTED WITH INDUSTRIAL AND SEWAGE EFFLUENTS

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ABSTRACT

The distribution of mycorrhizal fungi in soils polluted with sewage and industrial effluent is significantly altered compared to unpolluted soils, generally showing reduced diversity and root colonization. The specific effects depend on the type and concentration of pollutants and the resilience of native fungal species. The microbial communities including VAM fungi get affected by the sewage and industrial effluent. About this there is not much information. Soil polluted with industrial and sewage effluents supported less VAM population than non-polluted. 44 VAM fungi species were collected and indentified.

KEYWORDS: Effluents, Industrial, Sewage, Pollution, Soil, VAM Fungi

The distribution of mycorrhizal fungi in soils polluted with sewage and industrial effluent is significantly altered compared to unpolluted soils, generally showing reduced diversity and root colonization. The specific effects depend on the type and concentration of pollutants and the resilience of native fungal species. Industrial effluents contain a variety of toxic chemicals and heavy metals that negatively impact mycorrhizal communities and their symbiotic function.

The toxicity from industrial waste, including heavy metals, pesticides, and organic chemicals, causes a marked decline in the diversity, spore numbers and root colonization rates of Arbuscular Mycorrizal Fungi (AMF). One study on soil polluted by a sugar factory found that the number of AMF spores was lower in contaminated soil compared to unpolluted soil.

While overall diversity drops, certain stress-adapted AMF species may become dominant. In heavy metal-contaminated areas, species from the genera *Glomus* and *Acaulospora* have been found to be most common. Some *Glomus* species have also shown tolerance to tannery effluents. Some industrial pollutants, particularly toxic organic chemicals like pesticides, can inhibit key development stages of the fungi, including spore germination, hyphal growth, and the formation of arbuscules, which are crucial for nutrient exchange.

Studies have shown a negative correlation between heavy metal concentrations and the amount of glomalin- a glycoprotein produced by AMF- in the soil. Glomalin plays a key role in soil aggregation and can bind heavy metals, so its reduction negatively impacts both soil structure and the immobilization of contaminants. Sewage effluent introduces a different set of challenges, primarily high levels of nutrients and some contaminates, which also disrupt mycorrhizal pollutions.

Similar to industrial pollution, high levels of contamination from sewage effluent can significantly decrease the frequency and intensity of AMF colonization. This effect is often dose-dependent, with higher contamination levels causing greater reductions. Sewage in rich in nutrients like phosphorus and nitrogen. High levels of these nutrients can suppress AMF colonization, as plants may reduce their reliance on the symbiotic relationship for nutrient uptake.

While high levels are inhibitory, lower concentrations of sewage sludge have been shown to increase glomalin production and support plant growth, particularly when combined with inoculation of tolerant AMF species.

Research on mangrove ecosystems found that municipal sewage discharge most strongly inhibited the formation of functional arbuscules and vesicles, suggesting a reducing in the beneficial effects of the fungi. Indiscriminate use of pesticides, fertilizers and other pollutants cause undesirable changes in the soil ecosystem thus disturbing its physico-chemical set up and biological spectrum. Sewage effluents are a rich source of organic wastes, While industrial effluents contain many chemicals, including many heavy metals. The microbial communicate, including vesicular arbuscular mycorrhizal (VAM) fungi, may get affected by the sewage and industrial effluents. About this there is not much information. Hence, this study has been taken up.

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MATERIALS AND METHODS

In the present study, the soil which was distant from the effluent site and supported many weeds, grasses and other plant communities was considered as control (S_1 sandy loam). The soil site which received industrial effluents rich in caustic soda, acetic acid, soap, sodium silicate, ammonium sulphate, print colour and other effluents has been considered as the second sampling site (S_2 sandy silt loam). The third sampling soil site (S_3 sandy clay loam) received only sewage effluents and supported only on type of grass (Table-1). The soils were analyzed for VAM fungi quantitatively following the wet sieving and decanting technique (Gerdemann and Nicolson, 1963). Identification of VAM fungal genera upto species level was done using the manual for identification by Schenck and Perez (1990) (Table-2). The soils were analyzed for soil type, pH, soil temperature, moisture, chlorides, available nitrogen, available phosphorus, available potassium, organic carbon, ferric, manganese, zinc, copper, cobalt, nickel, lead and cadmium following standard methods (Table-3) (Issac and Kerber 1977; Karnaghan 2005; Chagnon *et al.* 2013; Smith and Read 2008; Dodd 2000; Schenblin and Van 2006; Hindumati and Reddy 2012; Van *et al.* 2008; Bever 2002).

RESULTS AND DISCUSSION

All the results show in table 1, 2 & 3. Mycorrhizal associations are found in a broad range of habitats. These include ecosystems ranging from aquatic (Khan and Belik 1995; Aguilar *et al*. 2009) to deserts, low and tropical rain forests (Janos 1987; Gai *et al.* 2009; Gaur and Adholeya 2004) to high altitude (Alen *et al.* 1987; Oehl *et al.* 2010) and in the canopy epiphytes, Vesicular arbuscular mycorrhizal (VAM)fungi are found in nearly all soils where plants grow, including environments that are considered stressful to plant growth.

However, only a few literatures have been published on the occurrence of VAM fungi in polluted habitants (Dueck *et al.* 1986) the isolation of heavy metal tolerance stains of VAM fungi and the effect of VAM fungi on the enhancement of heavy metal tolerance in plants such as grasses (Dueck *et al.* 1984), Onion (Gildon and Tinker, 1983) and Soybean (Ganesh, 1990). Earlier studies (Raman and Sambandan, 1998) revealed that *Glomus* species were prevalent in tannery effluent polluted soils, an indication of their adaptability to heavy metal exposure. Suitable mycorrhizal fungi and host plants will make them suitable in the tannery effluent polluted soils.

Selvaraj (1998) reported the occurrence of VAM of forty five different species of medicinal plants from four different soil sites of Thanjavur district. The association of VAM in *Dotura metal* (Govind Rao et al., 1989) and the occurrence of VAM fungi in aromatic plant cymbopogon species (Barthakar and Bordeloi, 1990) have been reported in medicinal plants. However, little information is available on VAM fungi and its effect on heavy metal tolerance, particularly on the efficiency of industrial and sewage effluent tolerant strain of VAM fungi.

Soil polluted with the industrial and sewage effluent supported less VAM population than non-polluted soils. Altogether 44 VAM fungal species were collected and indentified. The non-polluted soil contained 15 VAM species, whereas the soil polluted with industrial and sewage effluents harboured 26; only 9 species were found associated with the soil receiving sewage effluents. *Gigaspora* and *Scutellospora*, which were found in non-polluted soils were absent in the soil polluted with industrial and sewage effluents. *Glomus* was completely absent in the non-polluted soil.

Table 1: Number of VAM fungal propogules in 100 g soil of three sampling sites

Months	June 2024	Jul	Aug	Sept	Oct	Nov	Dec	Jan 2025	Feb	Mar	Apr	May
S_1	740	664	632	328	532	572	352	250	460	580	784	642
S_2	300	328	500	320	312	192	220	129	128	480	440	472
S_3	116	180	204	208	172	168	132	044	064	080	096	108

S_1 – Sandy loam, S_2 – Sandy silt loam, S_3 – Sandy clay loam

Table 2: Distribution of VAM species in non-polluted and polluted soils

VAM Species	S_1	S_2	S_3	000	VAM Species	S_1	S_2	S_3
Acaulospora appendicula	–	–	+		*G. flavisporum*	–	+	–
A. delicata	–	+	–		*G. geosporum*	–	+	–
A. denticulata	+	–	–		*G. hoi*	–	–	+
A. foveata	–	–	+		*G. intraradices*	–	+	–
A. lacunosa	+	–	+		*G. leptotichum*	–	+	–
A. laevis	–	+	–		*G. macrocarpum*	–	+	–
A. mellea	+	–	+		*G. maculosum*	–	+	–
A. nicoisonii	–	+	–		*G. manihotis*	–	+	–
A. spinosa	–	+	+		*G. mosseae*	–	+	+
A. tuberculata	–	+	–		*G. pustulatum*	–	+	–
Gigaspora albida	+	–	–		*G. reticulatum*	–	+	–
G. decipien	+	–	–		*G. tortuosum*	–	–	+
G. gigantean	+	–	–		*G. versiforme*	–	+	–
G. margarita	+	–	–		*Sclerocystis clavispora*	+	–	–
Glomus aggregatum	–	+	–		*S. coccogena*	–	+	–
G. botryoides	–	+	–		*S. pakistanica*	+	+	–
G. citricolum	–	–	+		*S. sinuosa*	+	+	–
G. claroideum	–	+	–		*Scutellospora albarosea*	+	–	–
G. delhiense	–	+	–		*S. calospora*	+	–	–
G. dimorphicum	–	+	–		*S. gregaria*	+	–	–
G. fasciculatum	–	+	–		*S. nigra*	+	–	–
G. fecundisporum	–	+	–		*S. reticulata*	+	–	–

S_1 – Sandy loam, S_2 – Sandy silt loam, S_3 – Sandy clay loam

Table 3: Physicochemical factors and statistical data

Factors	S_1 (Sandy loam)			S_2 (Sandy silt loam)			S_3 (Sandy clay loam)		
	1	2	3	1	2	3	1	2	3
pH	6.06	0.32005	1.06830	7.3	0.20362	0.65770	7.2	0.06088	0.19289
Moisture (%)	5.53	0.13123	0.41862	14.725	0.10022	0.31853	11.08	0.1722	0.55283
Temperature	37^0C	0.32505	1.08692	31^0C	0.24940	0.81442	29.7^0C	0.31252	1.04039
Bicarbonates	26.440	0.01534	0.04853	37.118	0.50049	1.82817	34.659	0.04123	0.13050
Chloride	11.700	0.50629	1.85656	114.74	0.36839	1.25311	22.072	0.17253	0.55390
Nitrogen (ppm)	70.58	0.03724	0.11786	124.32	0.10984	0.34947	247.21	0.45744	1.62674
Phosphorus (ppm)	29.52	0.40025	1.38117	32.9	0.23642	0.76944	125.2	0.038612	1.32370
Potassium (ppm)	107.8	0.37492	1.27891	125.3	0.182592	0.58729	200.5	0.18701	0.60201
Organic Carbon (%)	1.24	0.14364	0.45899	3.40	0.28379	0.93591	4.05	0.20566	0.66456
Iron (ppm)	108	0.19574	0.63121	163.1	0.19141	0.61672	218	0.70235	3.12020
Manganese (ppm)	9.63	0.51733	1.91166	6.70	0.20671	0.66811	16.7	0.34014	1.14385
Zinc (ppm)	2.023	0.22436	0.72808	6.37	0.14652	0.46840	2.99	0.05679	0.17990
Copper (ppm)	1.216	0.16028	0.51351	3.54	0.15952	0.51100	4.08	0.34572	1.16512
Cobalt (ppm)	8.091	0.02593	0.08204	10.17	0.32022	1.06892	12.67	0.4288	1.50101
Nickel (ppm)	0.629	0.48404	1.74928	30.39	0.10857	0.34537	2.132	0.33983	1.14266
Lead (ppm)	3.25	0.07940	0.25191	2.945	0.55385	2.10354	2.744	0.55385	2.10354
Cadmium (ppm)	0.103	0.15963	0.51135	0.119	0.28646	0.94552	0.153	0.50441	1.84734

CONCLUSION

The soils below neutral pH favoured more VAM fungal population while those with the pH range 7.02 to 8.1 had supported more VAM fungal species. Soil moisture was inversely related to VAM fungi. Chlorides, bicarbonates and nitrogen did not affect VAM fungal dynamics. The soils with moderate to less phosphorus content supported more VAM fungal population. Soils with less potassium, 1.3% organic carbon, 53 to 330 ppm of iron and 4.5 to 17.5 ppm of manganese favoured more VAM fungi. Nickel and lead were found toxic at higher levels. The soil type therefore affects the VAM fungi dynamics.

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