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Removal of Heavy Metal from Ground Water Using Phytoremediation Technique Case of Aurangabad

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Abstract: *Disposal of solid waste is one of the crucial issues, which is being faced by Indian cities today. Very few Indian cities have designed sanitary engineered landfill site for proper disposal of waste. Most of the cities practice the oldest form of waste disposal by dumping it on open ground. Waste lying on dumping ground decomposes resulting into formation of leachate and infiltration of the same in ground water. Ground water contaminated through leachate mostly has presence of heavy metals. The present study has attempted to reduce the concentration of heavy metal which is found in ground water due to improper waste dumping practices. Phytoremediation technique is adopted for removal of heavy metal from ground water and study has achieved removal/reduction in the same within a span of 10 days, with minimal cost.*

Key words: *Ground water; Heavy metal; Leachate; Phytoremediation; Waste dumping*

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I. Introduction

The pace at which urbanization is happening and is projected to increase manifold in near future, stress on provision and management of basic infrastructure services has increased substantially. Increasing population, changing lifestyle and consumption pattern has contributed in increasing quantity of solid waste generation. In India, as per census 2011 definition around 31.16% people are living in urban areas (7395 towns and cities), which generates approximately 62 million tons of waste per annum. From total amount of waste generated, around 70% waste is collected and 28% is treated, while rest is being dumped on land without any treatment. Total 1240 Ha of land will be required for waste disposal, if garbage is dumped at this rate without any treatment[I]. As per one estimate, annual waste generation will likely to increase up to 165 million ton by 2030. Very few cities have scientifically designed engineered landfill site for disposal of solid waste.

As per Municipalities Act, managing a solid waste is one of the mandatory responsibilities of municipal corporations/municipalities in urban area. Management of solid waste poses greater challenges to urban local bodies in terms of technical and financial capability. Due to lack of resources, urban local bodies are not capable to carry out efficient and effective management of solid waste; which has lead to unhygienic and unaesthetic conditions in our cities. Our cities have become a dump house of solid waste wherein piles of waste lies in and around city. The decomposition of organic waste at dumping site produces green house gases, contaminates water and soil, causing health hazards and other environmental problems.

The primary environmental problem of uncontrolled dumping of waste without treatment in open ground is generation of Leachate. Leachate is mostly used in the context of land filling, means a liquid that has harmful substances which may enter in to the environment. It is generated mainly from the compaction of solid waste deposited, which has higher moisture content. It contains toxic substances and if infiltrate into ground it will contaminate ground water which leads to possibility of entering into domestic water supply and ultimately in the food cycle. Areas near dump site have a greater possibility of ground water contamination from leachate. Such contamination of groundwater poses a substantial risk to local groundwater resource user and surrounding natural environment. Continues accumulation of leachate makes the water unfit for drinking purpose and results in many health effects.

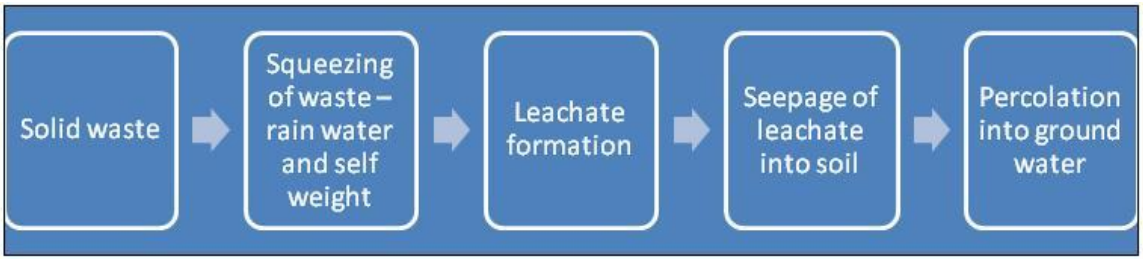

Figure 1: Formation of Leachate

1.1 Aurangabad – Solid waste management scenario

The study has focused on removal of heavy metal from ground water using phytoremediation technique in Aurangabad city of Maharashtra state. It is being called as the capital of Marathwada region in the state. City is a major tourism hub for national as well international tourists due to many historical monuments. Famous Ajanta – Ellora caves (declared as a world heritage sites) are situated near city. Aurangabad also houses other tourist spots such as Biwi ka Maqbara, Panchakki, Aurangabad caves, Salim Ali lake and Bird sanctuary. The city is also titled as **"The City of Gates"** due to presence of 52 gates. As per 2011 census, total population of the city is 1.17 million and total area of the city is 139 sq.km. Since 1936, Aurangabad Municipal Corporation (AMC) is the governing local body.

When it comes to solid waste management, city produces approximately 430 MT of waste every day[2]. Waste from the city is collected through private agency under door to door collection system by which around 70% waste is collected. Previously mixed waste is being collected, but due to administrative and other pressure urban local body started to collect segregated waste from different areas of the city. The city doesn't have any waste processing plant and waste is simply being dumped in area near Naregaon site. AMC has started to dump waste in total area of 44 acre at Naregoan in 1984.

Figure 2: Waste dumping practices at Naregaon, Aurangabad

The city came into limelight at national level recently, due to the issue of solid waste disposal. The petition was filed by a resident of Aurangabad for seeking directions to the state government to intervene in the standoff and ensure the urban local body disposes of solid waste as per the Solid Waste Management Rules 2016. The petition pointed out that the existing dump site at Naregaon is containing 10 to 20 lakh cubic meter of solid waste. The site is full of untreated waste and this has created health and hygiene issues. Therefore, there is a lot of protest for dumping garbage at Naregaon. Due to protest, garbage kept piling up in different parts of the city, as urban local body could not lift the waste for want of a disposal spot. The residents of Naregaon have refused to allow AMC trucks to dump garbage in their village[3]. Due to this, tons of solid waste in many parts of the city was in the state of decaying for almost a month. Eventually, state government intervened and sanctioned Rs.86.21 crore and directed AMC to prepare Detailed Project Report (DPR) within a year. Of total sanctioned amount Rs.30 crore will be given by the center and the rest will be provided by the state.

II. Material & Method

Area near Naregaon dumping yard was surveyed for the availability of ground water source. Toposheet was used to study the topography of the area. As per drainage flow pattern, heavy metal accumulation in soil and water is in the downstream side.

Figure 3: Toposheet (Source: Collected from Town Planning Department, Aurangabad)

Characteristics of site:

- Surrounding area of dumping yard is an agricultural land with haphazard residential development.
- Ground water from wells and tube wells is only used for agricultural purpose.

As the source of water in downstream side were minimal; station were located radially based on availability of water. From, total 11 stations ground water is collected from bore-wells, which is located around dumping site.

Figure 4: Total 11 stations/locations from where samples are collected

As the study focuses on the removal of heavy metals, determination of presence of heavy metal and its quantity becomes necessary. Analysis was done for three metals Arsenic, Copper and Manganese as per the availability of test kit.

- Syringe is used to add 5 ml sample solution into the reaction vessel.
- After that, AS/01 (one measuring spoon) reagent is added and rotated for one minute for better solubility.
- Then add one measuring spoon AS/02 reagent.
- Remove test strips (as and when required) and reseal the container immediately after use. During the process, do not touch the test paper zone.
- Afterwards, insert test strip with test field (2cm) into reaction vessel and clamp it with lid.
- 12 minutes is the reaction time, and during that time gently swirl the reaction vessel. Care should be taken that test field should not come in contact with the sample.
- After 12 minutes remove test strip from reaction vessel, and dip it for 2 second with the test field into the water, remove excess liquid.
- Finally, comparing test field to color scale.

- Fill aqua check test jar with 10 ml sample.
- Add 2 drops of reagent 046A-1 ,mix the content well
- Now add one drop of reagent 046A-2, mix the content and allow to stand for 5- 10 min.
- Match the developed colour with colour chart provided and the read the level of copper , mg/l (ppm)

- Fill the aqua,check test jar with 10ml sample.
- Add 10 drops of reagent 045A-1 , mix the content well
- Now add 5 drops of reagent 045A-2 mix the content well and allow to stand for 5 - 10 minutes.
- Match the developed colour with colour chart provided and the read the level of manganese mg/l (ppm)

Figure 5: Details of Aresnic, Copper & Manganese Kit
(Source: Biotechnology department, MGM, Aurangabad)

Results achieved are highlighted in table no.7. It shows heavy metal concentration in ground water sample of each station. The maximum quantity of Arsenic, Copper, and Manganese was determined at station 10 and 11 which are located very near to dumping site.

Table 1: Concentration of heavy metal in ground water near Naregaon dumping site

HEAVY METALS	ARSENIC (mg/l)	COPPER (mg/l)	MANGANESE (mg/l)
DESIRABLE LIMIT AS PER STD.	**0.05**	**0.05**	**0.1**
PERMISSIBLE LIMIT AS PER STD.	**-**	**1.5**	**0.3**
STATIONS			
1	10	50	10
2	10	50	10
3	10	50	50
4	10	0	30
5	5	50	50
6	5	50	50
7	10	50	50
8	20	50	50
9	20	100	100
10	20	150	100
11	20	150	100

2.1 Phytoremediation for removal of heavy metal

"Phyto = plant", "remediation = restore balance"

"The efficient use of plants to remove, detoxify or immobilize environmental contaminants in a growth matrix (soil, water or sediments) through the natural biological, chemical or physical activities and processes of plants", is known as Phytoremediation". In the process, natural properties of plants are used to remediate contaminated soils, water and sediments. It totally relies on ability of plants to take up and/or metabolize pollutants to less toxic substances.

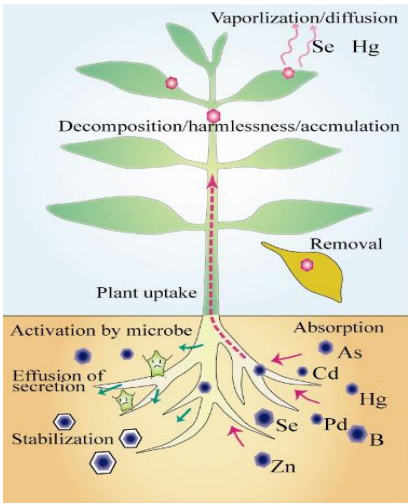

Figure 6: Process of removal of heavy metals through Phytoremediation
(Source: https://www.jrias.or.jp/report/pdf/2013-20E1.2.22.pdf)

However, uptake, accumulation and degradation of contaminants vary from plant to plant. Selection of plants for phytoremediation depends on its growth rate, biomass, ability to tolerate and accumulate contaminants, depth of root zone and potential to transpire ground water and also grow quickly in different conditions. For the present study water hyacinth is used, which is easily available in Aurangabad.

Floating cultivation method

- 30 plants of water are collected from lake near JNEC campus.
- Plants are washed properly to remove soil and other impurities from the roots and other parts of the plants.
- Total 60 liters of water is collected from STATION 11, which has recorded highest concentration of heavy metals (Arsenic, Copper, and Manganese).
- Then water is stored in the tank of size of 1m x 0.75m x 0.15m, having total volume of 112.5 litre.
- Water hycinth was grown in the collected sample and reduction in heavy metal concentration was observed in the time interval of 1,2,3,5,7, and 10 days respectively.

Figure 7: Floating cultivation method in practice

III. Results Achieved

The result of heavy metals accumulation is shown in table below.

Table 2: Results achieved in reduction of heavy metal by phytoremediation

HEAVY METALS	ARSENIC (mg/l)	COPPER (mg/l)	MANGANESE (mg/l)
DESIRABLE LIMIT AS PER STD.	**0.05**	**0.05**	**0.1**
PERMISSIBLE LIMIT AS PER STD.	**-**	**1.5**	**0.3**
Time duration			
1st day	16	150	100
2nd day	12	130	80
3rd day	8	95	50
5th day	5	40	20
7th day	2	8	5
10th day	0	0	0

Hence, it is concluded that Phytoremediation of ground water from Naregaon - dumping yard site is completely achieved for heavy metals i.e. Arsenic, copper, manganese.

1. Practical Implementation, Costing & Future Scope

For practical implementation, farm pond is constructed in agriculture field and water from the source is stored in it. Since, treating water with phytoremediation technique requires larger area and land; it is advisable to implement the technique in an agriculture area/ open areas where large chunk of land is available. Approximate construction cost of farm pond having area of 25 sq.mt, which treats 50,000 liters of water is Rs.30, 000 (including material and labour cost). Acquiring plants for phytoremediation doesn't costs much or in fact doesn't have a cost implication. The technology has proven its efficiency in removing heavy metals from contaminated water, which is suitable for all climatic conditions. At the same time its operation and maintenance is simple. It is a cost effective solution for contaminated sites. Phytoremediation of contaminated sites helps in preventing pollution, conserving resources (soil and water) and bringing back water to beneficial use. Considering the importance of phytoremediation, need of the hour is promotion and scaling of such cost effective, natural technology for removal of pollutants and restoring resources.

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