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Treatment Of Landfill Leachate By Using Nano Particals Of Titanium Oxide

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Abstract

Landfilling of solid waste is the most common method of disposing followed across the world. Landfill however generates huge quantity of leachate. Leachate is defined as the liquid formed when the solid waste comes in contact with moisture present and contains large amount of contaminants which are very harmful to living beings as well as environment. Nanotechnology has the efficiency in removing contaminants present in water including heavy metals eg (cadmium, arsenic, copper, lead, Mercury, nickel, zinc etc). Nanoparticles attract water and are repellent towards impurities and also repel organic matter and bacteria. Titanium dioxide or TiO2 has a characteristics that makes it suitable to many different applications. Titanium dioxide nanoparticle or ultrafine titanium dioxide are particles with diameter less than 100nm, they are transparent in nature hence are widely used in production of sunscreen lotion. Ultrafine titanium dioxide nanoparticle has strong absorption against both UV- A and UV- B radiation. The photocatalytic activity of TiO2 can be used to decompose impurities in wastewater. The study of titanium dioxide on leachate as treatment is

observed and the results are obtained by conducting an experiment.

Keywords: *Landfill Leachate, Nano Particals, Titanium Oxide, Heavy Metals,COD, TDS.*

INTRODUCTION:

Solid waste management: The process of collecting treating and disposing of waste material. The waste discarded are anything which are generated by human and animal activity which are no longer useful. Improper disposal of waste can create or affect environment. The task of solid waste management is to provide administrative economic and social solution to the problems that must be managed and solved.

Solid waste management is a global concern in both developing and developed countries. Despite providing awareness and describing the impacts of solid waste problems due to human activities there has been increase in solid waste generation. This could be due to increase in population industrialization and urbanization.
Methods of waste disposal: Landfill, Incineration / combustion, Recovery and recycling, Plasma gasification. Landfill is the most popular method of disposal of waste and most commonly used

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method for solid waste management in most parts of the world. They are carefully built on top of the soil or ground and are isolated from surrounding environment. Landfill are the site where rubbish, garbage and other sort of solid waste dumped. If

unattended or not taken care properly it may cause land pollution.

Effects of landfills: Air pollution and atmospheric effects, Groundwater pollution, Health effects, Soil and land pollution, Landfill fire, Odor. The waste which are so dumped in landfill results in the production of leachate and poisonous gases which are harmful to human health and affects the quality of environment.

Results of landfilling: Landfill gases: Of the gases produced in landfills ammonia, sulfide, methane and carbon dioxide of most concern. Ammonia, hydrogen sulphide are responsible for most of the odors at landfill. Methane produced has higher concentration sometimes exceeded explosive level indoors. 90 to 98% of landfill gases are made up of methane and carbon dioxide, the remaining 2 to 10% are nitrogen, ammonia, oxygen, hydrogen sulphides and other various gases. They are produced when bacteria are broken down into organic waste. The amount of gases depend on type of waves present in the landfill, age of landfill, oxygen content etc.

Leachate: It is formed due to the interaction between waste and the moisture, precipitation, snow no another liquid present in the soil in the landfill. It can also be the result of chemical and biochemical process within the landfill. Heavy metals are also collected in the leachate as it drains through the pile of wastes in the landfill land possess huge risk to human kind and environment. Therefore leachate management should also be considered as the main objective in solid waste management system. Leachate generation problem for solid waste landfills are they causes significant threat to surface water , groundwater and soil.

Effects of leachate: Ground water and Surface water contamination, Soil contamination. Groundwater and Surface water contamination: If groundwater table or surface water body lies near the landfill or under the landfill site chances of contamination is high. Concentration levels of different contaminants and presence of heavy metals might exceed and causes various problems and health disorders.

Soil contamination: Leachate percolated soil contains higher concentration of different contaminants. Thus soils with higher concentration might not be useful for agriculture, construction etc.

Hence to avoid such kind of contamination proper landfill liners which can control the leachate leaking into the water bodies and soil should be provided.

Methods of leachate treatment: Coagulation using lime, Alum, ferric chloride, Advanced techniques such as carbon adsorption, Physicochemical treatment, Aerobic biological treatment, Anaerobic biological treatment, Electrochemical oxidation, Nanotechnology.

Nanotechnology: Study and use of structure between 1 NM and 100 NM in size are called nanoparticles. It’s unique characteristics of having high surface area and can used and efficiently in removing most of the impurities from the waste water including heavy metals present in the water.

Application of nanotechnology: Promising technology in removal of impurities from water, Effectively purifies water, Able to degrade pollutants, Ground water remediation, Disinfectant, Less heat transfers compared to UV radiation, Medical use.

The objectives of the experiment are:

- To find the initial concentration of heavy metals in leachate.
- To find out the concentration of heavy metals present in soil, groundwater and surface water from surrounding area.
- To study impact of heavy metals to the environment and human.
- Treatment of leachate by nano technology method.
- To evaluate the removal efficiency of heavy metals from leachate by using different dosage of nano particle, different contact time and varying pH.

METHOD:

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Leachate sample was collected on 16 Jan 2020 from bellahalli landfill site. Sample was collected in a sample container and was then placed in refrigerator at minus 4 degree Celsius. Later the sample was given for testing for the determination of heavy metals to determine the availability in the landfill leachate.

Titanium dioxide [TiO2] is also known as Titania, naturally occurring oxide of titanium. When used as pigment it is called titanium white or pigment white 6. Generally it is source from ilmenite, rutile and anatase. It has wide range of application including paint, sunscreen and food coloring when used as food coloring it has E number. Titanium dioxide nanoparticle also called as ultrafine titanium dioxide or nano crystalline titanium dioxide or microcrystalline titanium dioxide are particles of titanium dioxide with diameter is less than hundred meters. Numerous studies have shown that many of the refractory organic matter in water can be efficiently degraded or removed by photocatalysis. Nanometer photocatalyst is the key factor in photocatalytic treatment of water pollution. N-type semiconductor materials such as nano-TiO, nano-ZnO is the most commonly used photocatalyst, in which TiO2 has shown many

advantages, such as wide band gap, chemical stability, non-toxic, catalytic effect, low price and so on, becomes one of the nano-catalysts with good application prospects.

STEP 1: Leachate sample collected was given for testing to check the levels of parameters present. Heavy metals parameters given for testing were:

Potassium, Chromium, Nickel, Cobalt, Copper, Zinc, Magnesium, Iron, Ammonia, Sodium, Lead, COD, Cadmium, Manganese, Organic matter.

STEP 2 : Amongst all the leachate treatment, Using of nanotechnology has seen the huge trend or has faced the great demand in environment because of positive results. Using nanotechnology for water treatment has resulted in 99% of removal of impurities. Nano membranes are used as water softeners and contaminants removal and providing safe water for use.

Nano technology are used for different purpose:

Remediation, Desalination, Filtration, Purification, Water treatment.

Experimental setup:

The different concentration of TiO2 nano powder was added as an adsorbent to 500mL of leachate. The characteristics of adsorbent are determined and tabulated. The properties of leachate was obtained during the initial testing

Adsorption capacity experiments were conducted in series of different dosage of nanostructured materials TiO2 powder was added to the leachate solution at 7.4 pH and the solution was stirred using magnetic stirrer for 30min to get uniform concentration, later the solution was left for settling for about 15min before sample were filtered through a filter membrane.

Effect of varying dosage of TiO2:

Batch experiments were conducted by mixing different sorbents masses of 50, 100, 200, 500 and 1000mg/l, while contact time remained 30 min and pH at 7.4.

Effect of contact time:

Batch experiments procedure were prepared with different contact time of 10, 20, 30, 40 and 60 min,

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while adsorbent dosage remained 100mg/L.

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Effect of pH:

The pH was adjusted using NaOH from range 3, 7 and 10, while adsorbent dosage remained 100mg/L and contact time was 30min.

Heavy metal adsorption analysis:

The concentration of heavy metals was measured atomic absorption spectroscopy. Atomic adsorption spectroscopy is an analytical technique that measures the concentration of elements. It is so sensitive that it can measure down to parts per billion of a gram in the sample. The technique makes use of the wavelength of light specifically adsorbed by an element.

STEP 3: The removal efficiency was calculated using:

% Removal = (c_i - c_f / c_i) x 100.

Where c_i is initial concentration of heavy metals in leachate and c_f is final concentration of heavy metals in leachate.

RESULTS AND DISCUSSION:

Parameters exceeding the tolerance limit in leachate sample:
Table 1. Analyzed report of leachate sample:

SL.N O	**METALS EXCEEDING THE TOLERANCE LIMIT**	**OBTAINED VALUE FROM TESTS IN mg/L**	**TOLERANCE LIMITS IN mg/L**
1	COD	4400	250
2	Chromium	1.107	0.1
3	Ammonia	237.25	50
4	Sodium	2300	60%
5	Iron	5.642	3
6	Potassium	2735	13-20
7	Magnesium	320.76	150

The above reports shows that, the parameters mentioned are exceeding the ISO standards of water quality for sewer water.

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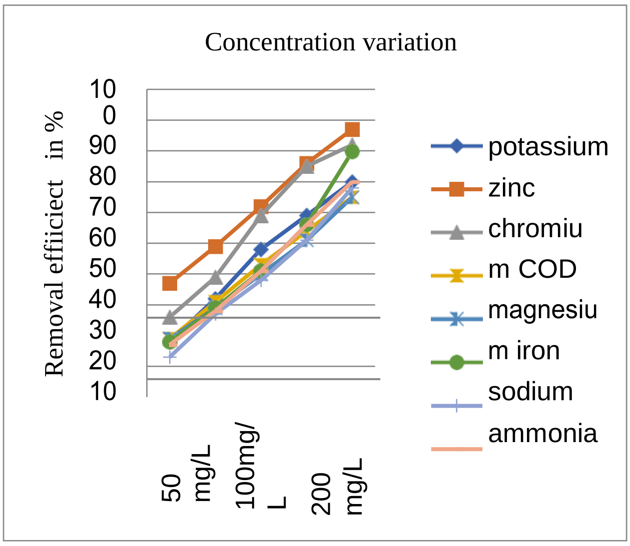
Removal efficiency due to varying dosage of nanoparticle.

Table 2: Removal efficiency by varying TiO2

Parameters	**Initial concentration in mg/L**	**Different dosage of TiO_2 added to the sample.**				
		50 mg/l %	**100 mg/l %**	**200 mg/l %**	**500 mg/l %**	**1000 mg/l %**
k	2735	18	32	48	59	70
Zn	1.029	37	49	62	76	87
Cr	1.107	26	39	59	75	82
COD	4400	19	31	43	54	65
Mg	320.76	19	29	40	51	65
Fe	5.642	18	29	41	56	79.77
Na	2300	13	27	38	51	68
NH_3	237.25	17	28	41	56	70



Dosage of TiO2 added in mg/L

Graph 1: Heavy metal removal efficiency at different concentration of adsorbent.
Graph 1 shows dosage of TiO2 added in mg/L on X-axis and removal efficiency in % on Y-axis. In this graph zinc is removed with best results of 87% removal efficiency at 1000mg/L dosage, pH at 7.4 and 30 min of contact time. The graph shows that as the dosage increases the removal efficiency also increases due to the increase in surface area between adsorbent and metals.

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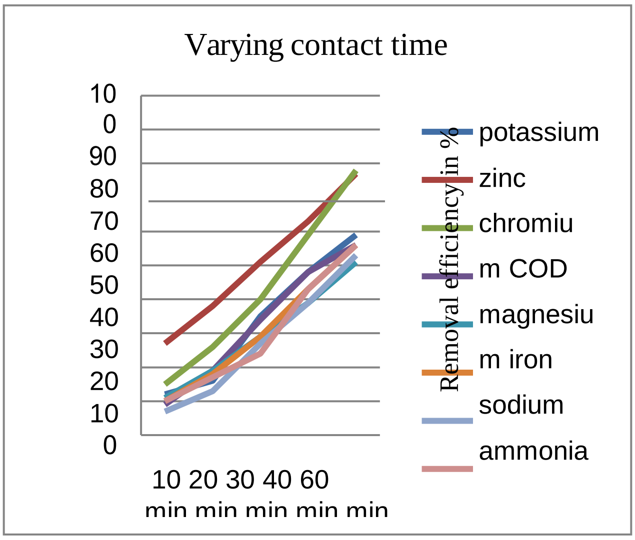
Removal efficiency due to varying contact time.

Table 3: Removal efficiency of various parameters at varying contact time

Para meter s	Initial Concent ration in mg/L	Varying contact time in the solution.				
		10m in %	20m in %	30mi n %	40mi n %	60mi n %
k	2735	12	16	35	48	59
Zn	1.029	27	38	51	63	77
Cr	1.107	15	26	40	59	78
COD	4400	09	19	34	48	56
Mg	320.76	11	19	29	39	51
Fe	5.642	10	18	29	43	56
Na	2300	7	13	27	39	53
NH3	237.25	10	17	24	43	56



Contact time in min

Graph 2: Removal efficiency at different contact time.

Graph 2 shows contact time in min on X-axis and removal efficiency in % on Y-axis. In this graph chromium is removed with best results of 78% removal efficiency at 60 min duration using 100mg/L dosage of TiO_2 ,pH at 7.4. Efficiency increases with increasing contact time due to higher reaction time between adsorbent and the metals

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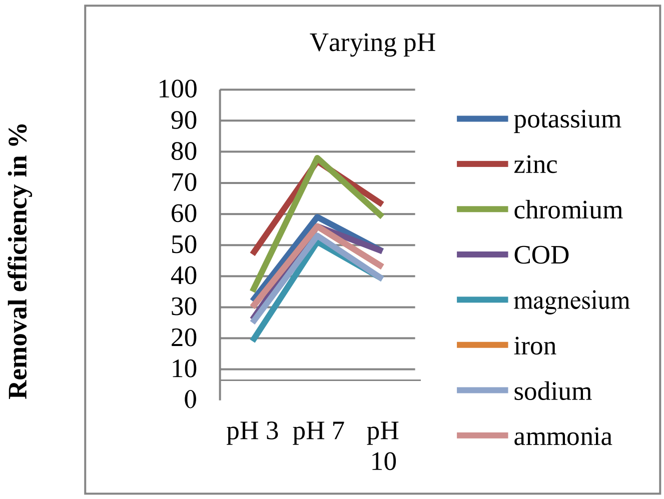
Removal concentration of heavy metals with varying pH.

Table 4: Removal efficiency of various parameters by varying pH.

Parameters	**Initial concentration in mg/L**	**Varying pH in the sample.**		
		pH =3 %	**pH =7 %**	**pH =10 %**
K	2735	32	59	48
Zn	1.029	47	77	63
Cr	1.107	35	78	59
COD	4400	26	56	48
Mg	320.76	19	51	39
Fe	5.642	30	56	43
Na	2300	25	53	39
NH3	237.25	30	56	43



Varying pH

Graph 3: Removal efficiency at different pH.

Graph 3 shows varying pH on X-axis and removal efficiency in % on Y-axis. In this graph zinc and chromium is removed with best results of 63% and 78% removal efficiency at 30 min duration using 100mg/L dosage of TiO_2 at pH 10 and pH 7.

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CONCLUSION:

The test results of initial concentration of parameters in leachate obtained shows that COD, ammonia, sodium, iron, potassium, magnesium and chromium exceeded the standard tolerance limit. Leachate was treated using nano TiO_2 powder as an adsorbent effectively.

Removal concentration results suggested that the adsorbent had a good adsorption effect on zinc with 87% of removal efficiency at 1000mg/L dosage of TiO_2 at pH 7.4 and contact time of 30 min. The initial concentration of zinc was 1.029mg/L and removal concentration was 0.1337mg/L. Chromium had a good adsorption effect of 78% of removal efficiency at 60min contact time at 7.4 pH and 100mg/L of adsorbent concentration. The initial concentration of chromium was 1.107 mg/L and removal concentration was 0.2435mg/L respectively. Zinc and chromium had a good adsorption effect of 63% and 78% of removal efficiency at pH 10 and pH 7 . The initial concentration of zinc and chromium was 1.029mg/L and 1.107 mg/L , final concentration was 0.3807mg/L and 0.2435mg/L . This shows that the adsorbents is a good and economical adsorption with broad application prospects.

As per the obtained results we can conclude that nano TiO_2 can be used to remove heavy metals from leachate effectively.

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