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STABILITY ENRICHMENT OF HEAVY METAL CHROMIUM DURING VERMI-FILTERATION OF INDUSTRIAL EFFLUENT

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ABSTRACT

This paper illustrated the potential effect of earthworms on heavy metal reduction in vermifiltration for liquid-state industrial effluent from four different station Bharath Heavy Electrical in Trichy. However, the analysis of heavy metal chemical speciation indicated earthworms made stabilisation heavy metals. Present investigation using principal component analysis revealed that transformations of heavy metal fractions were mainly due to the changes in effluent physico-chemical properties like pH, Biochemical oxygen demand, and Chemical Oxygen Demand etc., The results indicated that earthworms in vermifilter had a positive role in reducing heavy metal (Chromium (III)) containing Steel Industry effluent. The perusal of the results showed that BOD, COD, Chromium (III) was removed effectively. The maximum reduction of BOD by 87% COD by 86.45% and Chromium Bdl (below detection limit)was found in the effluent after vermifiltration processes with *Bacillus sp* and bio-vermifiltration treatment.

KEYWORDS: vermifilter, heavy metal, bio-vermifiltration.

INTRODUCTION

Recent studies found that VF (Vermifiltration) technology was feasible to reduce and stabilize liquid sludge under optimal conditions (Xing and Li X, Yang, 2010) found that the average volatile suspended solids (VSS) reduction of sludge treated by VF was 16.6% higher than that by BF (Bacillus Filtration) at the organic load of 1.12 kg-VSS/ (m^3d). There were few studies concern about the change and transformation of heavy metals during vermifiltration of liquid state sludge. The aim of the study will investigate the effect of earthworms on heavy metal Cr stabilization during vermifiltration of effluent. The sequential extraction procedure was employed to fractionize the chemical speciation of heavy metals in industrial effluent and to explore the transformation of these fractions (Sinha Rajiv, 2008). Charles Drawin explained earthworms have 600 million years of experience in environmental management (Drawin and Seward, 1903; Martin, 1976).

MATERIALS AND METHODS

The earthworm named *Eisenia fetida* were collected from Periyar Maniammai University, Vermicompost unit, Vallam, Thanjavur, Tamil Nadu, India. Liquid effluents were collected from Bharath Heavy Electrical in Trichy, Tamil Nadu, India and it was stored at 4° c to maintain their originality. Bedding materials consisting of straw and cow dung (Sarika Telang. and Hema Patel. (2013). All the materials used were completely sterilized. All the glass wares used were Borosilicate and they completely sterilized before and after used.

Vermifilter setup and process

The study was carried out in a vermi-filtration kit of size 45cm x 45cm x 90cm. The vermi-filtration kit contains a layer of sand and gravel with layer of garden soil on top. Provisions to collect the filtered water are made at the bottom through a pipe. The bottom most layer is made of gravel aggregates of size 20mm and above this there is a layer of gravel of size 10mm and top layer consists of gravel of size less than 10mm. These gravel layer fills up to a depth of 30 cm each of size 10 cm depth. Sand layer of depth 10cm is kept at the top of the vermifilter. The topmost layer of 20 cm depth consists of garden soil, where the earthworms were released as per in vermin-filtration kit (Damoodhar *et al*., 2014; Kavin *et al*,1997).). If the same process was done with the presence of bacillus *sp* then the final effluent was named as microbial- vermi filtered pre-treated effluent. The same procedure was carried out for all the four different samples (Industrial effluents).

Effect of time on pre-treatment of the effluent

100ml of four different samples (Industrial effluents) were taken in 500ml conical flasks each. Each conical flask was inoculated with 1ml *Bacillus sp*. Influence of time on pretreatment of effluent was determined by incubating the conical flask at 37˚C at 100 rpm for 72 hours and checked for its pH, BOD and COD and Chromium.

Pre-treatment of the effluent

The experiments were conducted on a lab scale, in the college laboratory. 100ml of four different samples (Industrial effluents) was taken in three 500ml conical flasks each. Each conical flask was inoculated with consortium pre-treated effluent with 1 ml of overnight cultures and incubated at 37˚C at 100rpm for 72 hours. Effect of pre-treatment effluent using selected strains and the trickled water was collected at the bottom outlet and checked for its pH, BOD, COD and Chromium.

Parameters estimated Values

- Temperature of the system - 37°C.
- Volumetric flow rate - 2 l/hr.

Vermifiltration of raw effluent

The reservoir was filled with 1l of raw effluent without pre-treatment, and was uniformly distributed at a flow rate of 2 l/hour to the surface of the vermifilter set up. The entire system was retained for 1hrs. After 1 hour the treated water was collected at the bottom outlet. The entire set up was allowed to convert the bedding material into humified vermicompost. The trickled water was collected at the bottom outlet and checked for its physiochemical parameter pH, BOD and COD etc., The same procedure was done for all the four samples.

Vermifiltration of pre-treated effluent

2 L/hr of raw effluent was pretreated with consortium at 37˚C for 72 hours with agitation (100 rpm). The reservoir was filled with 1L of consortium pre-treated effluent and was uniformly distributed at a flow rate of 2 L/hr to the surface of the vermifilter set up. The entire system was retained for 1hrs. After 1 hr the treated water was collected at the bottom outlet. The entire set up was allowed to remain to convert the bedding material into humified vermi compost. The trickled water was collected at the bottom outlet and checked for its pH, BOD and COD and Chromium. The same procedure was done for all the four samples.

RESULTS AND DISCUSSIONS

Raw effluent

Physicochemical parameter of the raw effluent was showed in the table (1.1) (1,2).(1,3),(1,4)

Raw effluent on vermifiltration

Vermifiltration of raw effluent results showed minimum reduction of BOD, COD and Chromium mg/l (Chaudhari, 2006; Gaiwad *et al.*, 2014).

Effect of *Bacilllus sp* pre-treatment of effluent with respect to time

Four different Industrial effluents were incubated at 37˚C at 100rpm in rotary shaker for 72 hours respectively with consortium pre-treated (Longmian Wang, 2011). Thus the effect of time on reduction of BOD and COD and Chromium by pretreatment was studied in detail. In our study, pretreatment with *Bacillus sp* at 72 hours gave the reduction of BOD in all the four samples in Table 1.b, 2.b,3.b, 4.b result showed by 44.18%, 52.89% 53.20% and 58.31% as well as gave the reduction of COD in all the four samples in Table 1.1, 1.2, 1.3, 1.4 result showed by 42.45 %, 45.89 %, 49.23% and 56.43 % as such as gave the maximum reduction of chromium in Milling samples by Bdl (below detection limit) which shows increase in contact time with microbes decreased the BOD,COD and Chromium level. Agitation at 100 rpm had a significant effect on the growth and activity of the enzyme producing microbes, for the reduction of organic content in the effluent which indicates the oxygen requirement in microbial pretreatment. The *bacillus sp* support the earthworm and increase the reduction of the heavy metals drastically in the vermifillter setup.

Effect of *Bacilllus sp* pretreatment on vermifiltration

The maximum reduction of BOD in Cutting sample by 87%, COD in Drilling sample by 86.45% and Chromium in Drilling sample by 98.83% was found in the effluent after vermifiltration process with *Bacillus sp.* treatment. Earthworm promote the growth of beneficial decomposer bacteria in waste water and act as aerators, grinders, crushers, chemical degraders, and biological stimulators (Dash, 1978 and Sinha, 2002). Earthworms communicate the substrate, thereby increase the surface area for microbial degradation constituting to the active phase of vermicomposting. The earthworm crushed organic matter passes through the gut it get mixed up with the gut associated microbes and digestive enzymes and finally leaves the gut in partially form of digestive material after the microbes take up the processes of decomposition contributing to the maturation phase (Li *et al.*, 2009).

Table -1.a: Examination of Physiochemical analysis of treated Iron and Steel Industry coolant effluent Sampling Station-Milling

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
Colour	Blackish	Colorless	Colorless	Colorless
Odour	Unpleasant	Odorless	Odorless	Odorless
pH	8.56±0.094	8.2±0.081	8.4±0.081	7.333±0.124
Temperature	27.333±1.247	23±0.816	25.66±0.471	22.333±0.471

Table -1.b: Examination of Physiochemical analysis of treated Iron and Steel Industry coolant effluent Sampling Station-Milling.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
EC µmho/cm	4234.33±79.34	3635±179.82	2714±7.11	442±2.160
TSS mg/l	982.66±10.873	744±29.69	704.66±3.299	230±1.699
TDS mg/l	5104±93.252	4428±2.44	2518±13.199	1214±2.943
BOD mg/l	882.66±9.285	683±45.963	492.66±5.73	316.33±7.845
COD mg/l	2488.33±34.740	1618±47.39	1432±17.281	698±6.480

Table -1.c: Examination of Physiochemical analysis of treated Iron and Steel Industry coolant effluent Sampling Station-Milling.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
Chloride mg/l	883±7.257	781±2.943	544±9.0921	275±0.816
Sulphate mg/l	445.33±4.988	369±0.816	259±7.363	186±2.160
Fluoride mg/l	1.51±0.043	1.266±0.047	1.0866±0.089	0.6±0.081
Iron mg/l	3.72±0.120	3.4±0.081	2.766±0.047	1.266±0.047
Oil & grease	13.50±0.032	10.63±0.16	7.466±0.094	6.733±0.094
Chromium mg/l	1.16±0.0.0736	0.791±0.003	0.232±0.002	Bdl

Synergistic action of enzymes, microbes and earthworms lead to considerable reduction of BOD, COD and Chromium. Studies have shown the gut of endogenic earthworms like *Eisenia fetida* having microbes with cellulolytic activity. There by reducing organic matter in the effluent wich indicates reducing the BOD, COD and heavy metal values (Jing Yang *et al*., 2013).

Table -2.a: Examination of Physiochemical analysis of treated Iron and Steel Industry coolant effluent Sampling Station-Drilling.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
Colour	Blackish	Colorless	Colorless	Colorless
Odour	Unpleasant	Odorless	Odorless	Odorless
pH	8.333±0.124	7.866±0.04714	7.4±0.141421	7.366±0.047
Temperature	25.33±0.471	25.33±0.471405	25.66±0.471405	25.66±1.247

Table -2.b: Examination of Physiochemical analysis of treated Iron and Steel Industry coolant effluent Sampling Station-Drilling.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
EC µmho/cm	4241±77.549	3855±154.7155	2610.66±27.39018	531.333±2.867
TSS mg/l	1101.33±27.980	1021±7.133645	703.33±0.942809	178.66±
TDS mg/l	6156.667±86.911	5616±34.4093	3237.33±16.75974	1360±3.2465
BOD mg/l	978±12.754	879±9.797959	460.66±2.494438	188±1.247219129
COD mg/l	2798.333±45.065	2485±19.61859	1514±5.887841	379±2.867441756

Table -2.c: Examination of Physiochemical analysis of treated Iron and Steel Industry coolant effluent Sampling Station-Drilling.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
Chloride mg/l	888.666±11.469	778±16.08	407.33±6.18	239±2.94
Sulphate mg/l	220±4.898	198.66±2.49	112±3.26	93.66±5.55
Fluoride mg/l	1.406±0.041	1.276±0.024	0.84±0.07	0.53±0.047
Iron mg/l	3.303±0.106	2.8±0.081	1.46±0.04	1.4±0.08
Oil & grease	13.666±0.205	10.43±0.63	8.46±0.71	6.53±0.85
Chromium mg/l	1.856±0.057	1.60±0.046	1.23±0.04	0.02±0.009

Table -3.a: Physiochemical analysis of Untreated Iron and Steel Industry coolant effluent Sampling Station-Cutting.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
Colour	Blackish	Colorless	Colorless	Colorless
Odour	Unpleasant	Odorless	Odorless	Odorless
pH	8.366±0.124	8.5±0.163299	8.233±0.04714	7.433±0.094
Temperature	27.66±0.471	27±0.816497	27.33±0.471405	26±0.816

Table -3.b: Physiochemical analysis of Untreated Iron and Steel Industry coolant effluent Sampling Station-Cutting.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
EC µmho/cm	4641.33±89.581	3837.33±70.05	2462±43.54308	507±3.741
TSS mg/l	1334.33±31.03	1056.33±96.59	661.33±4.109609	325.33±3.299
TDS mg/l	6048.667±57.644	4855.33±26.54	2928±17.04895	1535.667±6.649
BOD mg/l	910.333±13.274	696.33±45.75	426±4.898979	118.33±16.21
COD mg/l	2860±48.020	2511.33±12.25	1432±3.265986	435.33±99.73

Table -3.c: Physiochemical analysis of Untreated Iron and Steel Industry coolant effluent Sampling Station-Cutting.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
Chloride mg/l	804.666±6.599	713.66±15.369	378.66±5.24	164.666±2.054
Sulphate mg/l	340±5.715	298.66±4.496	171.66±2.86	119.33±4.98
Fluoride mg/l	1.306±0.047	1.07±0.008	0.66±0.047	0.433±0.047
Iron mg/l	3.496±0.053	2.83±0.205	1.56±0.047	0.7±0.081
Oil & grease	14533.±0.169	11.13±0.47	7±0.08	3.76±0.12
Chromium mg/l	1.426±0.036	1.22±0.085	0.66±0.094	0.02±0.008

Table -4.a Physiochemical analysis of treated Iron and Steel Industry coolant effluent Sampling Station-Grinding.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
Colour	Blackish	Colorless	Colorless	Colorless
Odour	Unpleasant	Odorless	Odorless	Odorless
pH	8.5±0.081	8.5±0.08165	8±0.16	7.5±0.081
Temperature	26.66±0.471	28.3±0.471405	28±0.81	28.33±0.471

Table -4.b: Physiochemical analysis of treated Iron and Steel Industry coolant effluent Sampling Station-Grinding.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
EC µmho/cm	347.66±47.232	2976±20.46135	1172±711.36	488±6.976
TSS mg/l	5216±78.383	749.66±28.39405	453±6.48	199±0.81
TDS mg/l	964±6.976	4121.33±27.77689	2338.33±14.70	1182.66±3.29
BOD mg/l	785.333±13.474	655.66±6.128259	327.33±4.98	121±5.09
COD mg/l	2114±38.218	1787.33±51.49326	921±11.22	359.33±37.98

Table -4.c: Physiochemical analysis of treated Iron and Steel Industry coolant effluent Sampling Station-Grinding.

Parameter	Raw effluent	Vermifilteration	Microbial treatment	Biovermifilteration
Chloride mg/l	854.666±13.097	655.33±9.46338	334.66±6.79	242±1.63
Sulphate mg/l	366.666±7.717	325.66±4.642796	125±4.54	144±0.81
Fluoride mg/l	1.77±0.043	1.42±0.021602	0.89±0.04	0.86±0.04
Iron mg/l	5.24±0.053	4.26±0.04714	2±0.08	1.9±0.29
Oil & grease	13.566±0.286	11.33±0.094281	5.23±1.08	5.26±0.55
Chromium mg/l	1.426±0.036	1.16±0.01633	0.88±0.04	0.30±0.02

Physio Chemical Parameter of Variation in pH, BOD, COD, and Chromium Value of treated waste water.

Result indicates that the minimum of pH was observed in treated effluent. The presence of BOD is indicates the organic load of wastewater. The BOD load in effluent was varied in vermifiltration unit with pretreatment was significantly lower than initial levels and integrated Bio-vermifiltration showed more removal efficiency. Result shows that the earthworms can remove BOD load by over 87% in Table 3.b Result showed that the average COD removed from the wastewater by Bio-vermifiltration with pretreatment is over 86.45% in Table 2.b indicating degradation of several chemicals by enzymes in the gut of earthworms which is not usually degraded by microbial pretreatment. Earthworm body act as a biofilter respectively by ingestion and biodegradation of organic wastes, heavy metals and solids from waste water their adsorption through body wall (Anusha and Sham Sundar, 2015). The presence of heavy metal in Iron and steel industry effluent is almost removed by Bdl in Table 1.c Vermifiltration of the effluent pretreated using bacterial culture at optimum condition showed the maximum reduction of chromium (Jing Yang *et al*., 2013).

CONCLUSION

Integrated Bio-vermifiltration technique for the treatment of industrial liquid effluent was developed. It is a decentralized and cost effective method which can be applied to treat both domestic and industrial waste water treatment (Divya, 2015.). A huge reduction in various effluent parameters like BOD, COD was observed. Presence of heavy metal chromium in Industrial effluent is almost nil. Vermifiltration of the effluent pre-treated using the bacterial consortium at optimum conditions showed maximum reduction in the above mentioned parameters.

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