A Review on Effectiveness of Earthworms for Treatment of Wastewater

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***Abstract* - This review paper shows the effectiveness of earthworms during treatment of waste water. They are used to treat organic pollutants from waste water using mechanism of degradation. Earthworms enhanced the stabilization of organic matter. They are generally known as environmental engineers. They generally remove average COD 84.4%, BOD 91.8%, TDS 97% & TSS 97.4% respectively. It is found that out of all earthworms *E. Fetida* is highly effective than other worms. It also helps in the treatment of different industrial waste water of Dairy, Geltine, Palm oil mills and fruit industries.**

***Keywords* - Earthworms,E.Fetida,waste water,organic matter**

I. INTRODUCTION

Earthworm body works a biofilter which widens the microbial metabolism by increasing their population. It also grinds, aerate, crush, degrade the chemicals and act as biological stimulator. Microbial and Vermi processes will simultaneously work by treating the wastewater using earthworms. Effluent resulted will be extremely rich in nutrition and can be reused as earthworms are versatile waste water eaters and decomposers **(Lakshmi et al. 2014).** Earthworms have over 600 million years of experience as "ecosystem engineers". Vermiculture scientists all over the world knew about the role of earthworms as waste managers, as soil managers & fertility improvers and plant growth promoters for a long time. But nowadays they are used in waste water treatment and contaminated soil remediation. About 4,400 different species of earthworms have been identified, and quite a few of them are versatile waste water eaters and biodegraders and several of them are bio-accumulators & bio-transformers of toxic chemicals.

II. GENERAL CHARACTERISTICS

Earthworms are long, narrow, cylindrical, bilaterally symmetrical, segmented animals having without bones. The body is dark brown, glistening, and covered with delicate cuticle. They weigh over 1400–1500 mg after 8–10 weeks. . Usually the life span of an earthworm is about 3–7 years, depending upon the type of species and the ecological situation. Earthworms harbor millions of nitrogen fixing and decomposer microbes in their gut. They have chemoreceptors which aid in search of food. Their body contains 65% protein (contains 70–80% high quality lysine rich protein), 14% fats, 14% carbohydrates, and 3% ashes. Earthworms are generally absent or rare in soil with a very coarse texture and high clay content or soil with pH<4. Earthworms are also tolerant to moderate salt salinity in soil, but some species like the tiger worms (*Eisenia fetida*) has been found to be highly salt tolerant and resistive towards chemicals. **(Sinha et al 2010)**

Ecology and Biology of Earthworms

Earthworms can also tolerate toxic chemicals in the environment. As worms breathe through their skin proper ventilation of air in soil medium is necessary. They can tolerate a temperature range between 5^0 and 29^0 C. A temperature of 20^0–25^0C and moisture of 60–75% are optimum for best worm function. Generally earthworms can also tolerate extensive water loss by dehydration. Earthworms are bisexual animals and multiply very rapidly. After copulation each worm ejects lemon-shaped 'cocoon' where sperms enter to fertilize the eggs. Studies indicate that they double their number at least every 60–70 days. Given the optimal conditions of moisture, temperature, and feeding materials earthworms can multiply by 2^8, i.e. 256worms every 6 months from a single individual. The total life cycle of the worms is about 220 days. Red worms take only 4–6 weeks to become sexually mature (**Sinha et al. 2008**). They have been reported to bio-accumulate them in their tissues and either biodegrade or bio transform them into harmless products with the aid often enzymes. They have also been reported to host microbes in their gut which can biodegrade chemicals. **(Rani et al. 2013)**

Economic Significance

Earthworms can physically handle most organic waste water and potentially at a fraction of the cost of conventional methods of wastewater treatment. Vermiculture technology by earthworms is a self promoted, self regulated, self improved, self driven, self powered and self enhanced, very low energy and less chemical requiring zero waste technology, easy to construct, operate and maintain. Any vermiculture technology involves about 100-1000 times higher 'value addition' than other biological technologies. It has less operational cost since it requires energy only for pumping of waste and no skilled labor. Maintenance costs also minimal as it does not involve any mechanical devices **(Sinha et al. 2008)**

Mechanism of Earthworms in Wastewater Treatment

Earthworms are versatile waste eaters and decomposers. It promotes the growth of beneficial decomposer bacteria in waste water and acts as an aerator, grinder, crusher, chemical degrades and a biological stimulator.

The two processes-microbial processes and vermin-process simultaneously work in the Vermifiltration system. Earthworms further stimulate and accelerate microbial activity by increasing the population of soil microorganisms and also through improving aeration by burrowing action. Earthworms host millions of decomposer microbes in their gut and excreta called vermicast. The nutrients N and P are further used by the microbes for multiplication and enhanced action. Studies show that the number of bacteria and actinomycetes contained in the ingested material increased up to 1000 fold while passing through the gut. A population of worms numbering about 15000 will in turn fosters a microbial population of billions of millions.

Synergistic action of Enzymes, Micro Organisms and Earthworms in Vermifiltration

The role of different types of enzymes, microorganisms, and earthworms for effluent treatments has been studied. **Kavian and Ghatnekar (1999**) carried out extensive studies on celluloses from *L. rubellus*. Their studies confirmed that enzymes can act on specific recalcitrant pollutants to remove them by precipitation or transformation to other products .They can also change the characteristics of a given effluent to render it more amenable to treatment or aid in converting effluent material to value added products.

Kavian and Ghatnekar (1999) also carried studies on the bio management of dairy effluents using an *L. rubellus* culture and concluded that sludge cake could support the growth of earthworms without processing. They also studied about the bio management of paper mill sludge using vermiculture biotechnology. *L .rubellus* was used to treat approximately 1.5 tones of the sludge coming out of the mill daily. The sludge was successfully converted into biofertilizer and plant tonics.

The research study of **Hamdi et al (1991)** analyzed the use of *Aspergillus Niger* as an efficient means of protein waste bio conversion while working on waste water from olive mill. **Kavian et al (1998)** demonstrated the utility of fungal species via *A. flavus* and *A. Niger* in the treatment of pharmaceutical waste. **Ghatnekar et al (2009**) also reported bio management of liquid effluents discharged after secondary treatment from the gelatin manufacturing industry using combination of *A. flavus* and *A. Niger*.

III. IMPORTANCE OF EARTHWORMS IN VERMIFILTRATION

Organic matter degraded by microorganisms was further digested by colonies of earthworms living in bedding material. Various actinomycetes inhabiting the earthworm's guts also triggered degradation of solid contents. Studies reported an intensified bacterial diversity in the waste water due to the presence of earthworms (*Eisenia fetida*), especially in response to nutrients in their casts.

Earthworms and microorganisms cooperate in Vermi Filter ingests and biodegrade organic wastes and other containments in waste water. This extends the food chain in normal bioprocesses and thus greatly improves sewage treatment efficiency.

Earthworms increase the hydraulic conductivity and natural aeration by granulating clay particles .They also grind silt and sand particles, increasing the total surface area, which enhances the ability to adsorb organic and inorganic from waste water. Intensification of soil processes and aeration by earthworms enable the stabilization of soil and the filtration system to become effective and smaller in size.

The researcher observed that the presence of earthworms in effluent led to significant stabilization of sludge by enhancing the reduction of volatile suspended solids. Specially, earthworms on the waste water were capable of transforming insoluble organic materials into a soluble form and then select digesting the sludge particles to finer states, which facilitated degradation of organic material by the microorganisms in the reactor. The studies concluded that ammonia had very low toxicity on the survival of earthworms in the waste water. In this study there were no observation and adverse effects of the selected effluents on the earthworm population. (**Ghatnekar et al 2010)**

Potential application of Earthworms in Wastewater treatment

Long-term researches into vermiculture have indicated that the Tiger Worm (*Eisenia fetida*), Red Tiger Worm (*E. andrei*), the Indian Blue Worm (*Perionyx excavatus*), the African Night Crawler (*Eudrilus euginae*), and the Red Worm (*Lumbricus rubellus*) are best suited for Vermi-treatment of a variety of solid and liquid organic wastes under all climatic conditions.

Researchers done many experiments into field of waste water treatment technologies and found that *E.fetida* earthworms are effective for treatment of waste water and have sufficiently treated wastewater from different industries.

Results and Discussions

Following are the treatment efficiency of earthworms for different wastes from domestic as well as different industries.

Table 1 Efficiency of Earthworms for various types of Wastewater and Sludge

S.No	Types of waste water/sludge	Earthworms used	Removal Efficiency/Major observations	References
1	Domestic waste water	*Eudrilus Eugenia*	BOD=85-93% COD=74-80%	Kharwade et al. 2011
2	Gelatine Industry	*Lumbricus Rubellus*	COD=90.8% BOD=89.2%	Ghatnekar et al. 2010

3	Rural domestic waste water	*E.Fetida*	COD=81.3%	Meiyan et al. 2010
4	Palm oil mill effluent	*Eudrilus eugeniae*	COD=71-84% TSS=81-85%	Tengku et al. 2013
5	Domestic wastewater (assessment of toxicity of ammonia on earthworm in vermi biofiltration system)	*Eisenia fetida*	High salt concentration may cause damage to earthworms in Vermifiltration units	Hughes et al 2011
6.	Liquid waste products from dairy industry	*E. fetida*	Removal of 5 day BOD by 98%, COD by 80–90%, TDS by 90–92% during the process	Sinha et al 2006
7.	Treatment of sewerage and sludge	*E. fetida*	Removal of COD by 81–86% and BOD by 90–98% during vermibiofiltration	Xing et at 2013

IV. CONCLUSION

Earth worms are tireless tillers of our soils and their castings are richest and best of all fertilizers. They are very useful in treatment of waste water as well as sludge. They are also useful for treatment of waste water from industries as well as domestic and residential sewage. Their removal efficiency is about 80-90% for BOD and 70-80% for COD. They stabilized organic matter and converted to stable product. Among all earthworms *E.Fetida* is best suited for treatment of waste water from different fields.

V. REFERENCES

1. Sinha, R K., Bharambe, G., and Bapat, P. 2006 , Removal of high BOD and COD loading of Primary liquid waste products from Diary industry by vermifiltration technology using Earthworms , IJEP 27 (6) : 486-501.
2. Ghatnekar, S. D ., Kavian, M. F., Sharma, S. M., Ghatnekar, S. S., Ghatnekar, G. S , Ghatnekar, A. V. 2010 , Application of Vermi- filter based effluent treatment plant(pilot scale) for bio management of liquid effluents from gelatin industry ,dynamics soil, dynamic plant 4 (special issue I), 83-88.
3. Hughes R. J., Nair J., and HOG., (2011), "The risk of sodium toxicity from bed accumulation to key species in the vermifiltration waste water treatment process", Bioresource Technology, 100 ,16:3815-3819.
4. Jing Liu, Zhibo Lu, Jian Yang, Meiyan Xing, Fen Yu, Ceramsite-vermifilter for domestic wastewater treatment and reuse: an option for rural agriculture, 2009 International Conference on Energy and Environment Technology.
5. Meiyan, X., Xiaowei, L., and Jian, Y., 2010 , Treatment performance of small-scale vermifilter for domestic wastewater and its relationship to earthworm growth, reproduction and Enzymatic activity, African Journal of Biotechnology Vol. 9(44), pp. 7513-7520, November, 2010.
6. Rani, S., Bansal, N., , Shukla, V. 2013 ,Earth worms : eco friendly Environmental Engineers, Journal of Biology and Earth Sciences, ISSN:2084-3577.
7. Jian Yang, Chunhui Zhao, Meiyan Xing, Yanan Lin, Bioresource technology, volume 146, October 2013,page 649-655.
8. Jian Yang, Jing Liu, Meiyan Xing , Zhibo Lu, Qiong Yan 2013, Effect of earthworms on the biochemical characterization of biofilms in vermifiltration treatment of excess sludge, biotechnology resources , volume 143, September 2013 , pages 10-17.
9. Meiyan Xing, Chunhui Zhao, , Jian Yang, Baoyi Lv, Feeding behavior and trophic relationship of earthworms and other predators in vermifiltration system for liquid-state sludge stabilization using fatty acid profiles, Bioresource Technology, volume 146,October 2014,page 149-154.
10. Xiaowei Li, Meiyan Xing, JianYang, LiminZhao, Xiaohu Dai 2013, Organic matter humification in vermifiltration process for domestic sewage sludge treatment by excitation–emission matrix fluorescence and Fourier transform infrared spectroscopy.journal of hazardous material, volume 261,15 October
11. Sudipti Arora, Ankur Rajpal, Tarun Kumar, Renu Bhargava and A.A. Kazmi 2014, Pathogen removal during wastewater treatment by vermifiltration, Environmental Technology, 2014Vol. 35, No. 19, 2493–2499.
12. Longmian Wang, Zheng Zheng, Xingzhang Luo, Jibiao Zhang 2011, Performance and mechanisms of a microbial-earthworm ecofilter for removing organic matter and nitrogen from synthetic domestic wastewater, Journal of Hazardous Material, volume 195,15 November 2011,page 245-253.
13. Tarun Kumar, Ankur Rajpal, Renu Bhargava, K.S. Hari Prasad2014, Performance evaluation of vermifilter at different hydraulic loading rate using river bed material, Ecological Engineering, volume 62,January 2014,Page 77-82.
14. Reidun Pommeresche 2009 , Anne-Kristin Loes Relations between Agronomic Practice and Earthworms in Norwegian Arable Soils, Dynamic Soil, Dynamic Plant
15. Rajiv K. Sinha ,Gokul Bharambe ,Uday Chaudhari 2008, Sewage treatment by vermifiltration with synchronous treatment of sludge by earthworms: a low-cost sustainable technology over
16. conventional systems with potential for decentralization, Springer Science Business Media, LLC 2008

17. LongmianWang, ZhaobingGuo, YuxiaoChe, FeiYang, JianyingChao, YuexiangGao, YiminZhang, The effect of vermifiltration height and wet: dry time ratio on nutrient removal performance and biological features, and their influence on nutrient removal efficiencies, Ecological Engineering, volume 71, October 2014,Page 165-172.
18. Jorge Domínguez, Manuel Aira 2012, Twenty years of the earthworm biotechnology research program at the University of Vigo, Spain, International Journal of Environmental Science and Engineering Research (IJESER), IJESER Vol 3(2):01-7, 2012.
19. Priyanka Tomar, Surindra Suthar 2011, Urban wastewater treatment using vermi-biofiltration system, Desalination, Volume 282,1 November 2011,Pages 95-103,current development of wastewater treatment in India.
20. Rajiv K. Sinha, Sunita Agarwal, Krunal Chauhan, Vinod Chandran, Brijal Kiranbhai Soni 2010, Vermiculture Technology: Reviving the Dreams of Sir Charles Darwin for Scientific Use of Earthworms in Sustainable Development Programs, Technology and Investment, 2010, 1, 155-172.