

VERMICOMPOSTING OF TEXTILE SLUDGE USING PERIONYX EXCAVATES

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Abstract: The present study investigated the potential for textile sludge treatment using vermicomposting process by *Perionyx excavatus*. Composted water hyacinth was added to improve the nutritional values of sludge. Different treatments were created with different ratios of composted water hyacinth mixed with textile sludge as feed mixture. Treatments were put in darkness and their moisture content was maintained at 50 – 60%. pH, total nitrogen, total phosphorus and Cr³⁺ content were measured during initial and final period of the study. Fertilizer potential of end product was evaluated based on the nutritional values of the product.

Key word: Textile sludge; Vermicomposting; Water hyacinth; *Perionyx excavatus*

1. INTRODUCTION

In Vietnam, particularly in Ho Chi Minh City, the textile dyeing industry has been rapidly developing. In 2012, total export turnover for textile industry and total textile fiber industry reach 17.2 billion USD. None the less, as the industry is expanding, the problem of managing textile sludge disposals also draws a great deal of attention. Textile dyeing and printing operations produce a significant amount of polluted waste effluents. Treatments of the effluents by chemical and biological means often involve a solids separation process, which results in the retained textile sludge (Bhalerao *et al.*, 1997). Balan and Monteiro (2001) studied and showed that in textile sludge there were organic compounds, chemical substances, heavy metals and aromatic dyes, which can cause severe hazards to not only human health but also the environment. Wool fabric dyeing and finishing sludge, for example, constituted 0.7 mg/kg Cadmium and 267 mg/kg Chromium.

However, appropriate measures to safely dispose textile sludge have not been seriously taken. Although destructive methods, such as incineration, are available, they are not often employed owing to the cost and the limited landfill sites in Ho Chi Minh City. Therefore, such sludge is usually observed to be openly dumped at various abandoned sites around the

city, or buried in landfill. Such practice does not only incur health problems to the public due to water and soil pollution of the dumping sites, but also a waste of valuable organic and inorganic matters in the sludge. Therefore, this toxic sludge should be treated and recycled to protect the environment. Therefore, the idea of this study is to explore a method to satisfy the need.

Vermicomposting, the process of composting using earthworms, has been proven to be a reliable method to deal with the earlier mentioned problem. Charles Darwin (1881) highlighted in his last scientific book that earthworms have an essential role in the breakdown of organic matters and the release of nutrients from them to improve the quality of soil. From this concept, on one hand, several studies have been conducted to further illustrate the ability of earthworms to digest cattle dung (Edwards *et al.*, 1985), cow slurry (Hand *et al.*, 1988), mango leaves (Talashilkar *et al.*, 1999), paper waste (Gajalakshmi *et al.*, 2002), etc. On the other hand, only a few researches applying vermicomposting into bio-recycling industrial solid wastes and study the growth of earthworm as well as chemical properties and microbial mass in the process. Elvira *et al.* (1996) used vermicomposting to degrade paper-pulp mills sludge and figured out that earthworms can speed up mineralization of organic matter. Never the less, industrial sludge alone cannot be a sustainable feed for the growth of earthworms, hence to provide sufficient nutrients and an inoculum of microorganism, raw sludge need to

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be mixed with other nitrogen-rich media (Elvira *et al.*, 1998). To further emphasize this point, it is now known that textile mills sludge can be used as raw feeds to earthworms without prior treatments when the former is mixed up to 30% with cow dung (Kaushik and Garg, 2003). Hence, this study, employing the concept of mixing sludge with nitrogen-rich materials, explores vermicomposting's influences on the growth of earthworms using composted water hyacinth.

In previous studies, earthworm species of genus *Eisenia* are often used, owing to its wide distribution worldwide (Edwards *et al.*, 2010). None the less, in the same books, Edwards *et al.* (2010) also highlighted that the optimum temperature for *Eisenia* earthworms to grow is approximately 25°C, which is difficult to maintain in the setting of this experiment in tropical countries like Vietnam. Meanwhile, in this tropical region of Asia, *Perionyx excavatus* (Perrier), an epigeic species, is commonly known (Gates, 1972). It is easy to handle, greatly prolific and it can withstand as high temperature as 30°C (Edwards *et al.*, 2010). Previous studies by Suthar (2007) and Suthar and Singh (2008) for vermicomposting of *P. excavatus* with agriculture waste and domestic waste, from which it was concluded that the species demonstrate a high rate of mineralization for end products, and also high growth and reproduction. In this study, to further utilize the effectiveness of using *P. excavatus* in vermicomposting, its growth in textile mill sludge will be investigated.

The water hyacinth, *Eichhornia crassipes*, is widely spread in Vietnam. The plant can most likely observed present along the rivers, the water bays and so on. Water hyacinth can cause several problems namely obstructing waterways, impeding drainage, and lowering dissolved oxygen levels resulting in available oxygen for other organisms in the same living environment (Gopal, 1987). Therefore, the problem of such aquatic weed like water hyacinth must be addressed urgently with an appropriate method, to not only cost effective but also to recycle the nutrients in the plant. In order to better managing the plant, the use of the plant to feed

the animal, for compost, for fertilizer, and for water pollution control has been practiced (Gopal, 1987). As water hyacinths decay, the plant releases a significant amount of nitrogen into the water body. Although such issue possesses a threat of eutrophication to the aquatic environment, at the same time it can benefit the soil if a suitable procedure is applied. As a result, this study purposely put composted water hyacinths to further observe whether composted water hyacinth can provide sufficient nitrogen required for vermicomposting.

Rationale of study is to avoid problems incurred to human health and the environment in Vietnam by poor management of textile mill sludge, and to recycle it to a safe and valuable product. Vermicompost, which is high in nutrients and bio-friendly to the environment, proves to be capable for the call. The aim of this study is to investigate the ability of *P. excavatus* in vermicomposting of textile mills sludge. The potential of the compost which can be used as an agronomic valuable product is assessed via physiochemical properties and microbial population quantification.

2. MATERIALS AND METHODS

2.1 Materials

Fresh water hyacinth plants were collected along the riverside in Thanh Da, HoChiMinh City. They were minced and mixed with cow manure in ratio of 2:1, moisture maintained at 60 to 70%, then put in aerobic condition to allow composting process to take place. After 30 days or more, composted water hyacinth (CWH) was obtained for experiments. The main characters of CWH were pH = 6.85, Total Kjeldahl nitrogen (TKN) = 3262.33 mg/kg, Total phosphorus (TP) = 90.00 mg/kg, and chromium content (Cr^{3+}) = 6.68 mg/kg.

Raw textile sludge (TS) was obtained from the wastewater treatment plant of ULHWA Vietnam Ltd. located in Bien Hoa city, Dong Nai province. The main characteristics of TS were pH 4.95, TKN of 1221.95 mg/kg, TP of 0.82 mg/kg, and chromium content (Cr^{3+}) = 3.80 mg/kg. In prior to vermicomposting process, the sludge was put to dry in a shaded open air area.

Stock cultures of *P. excavatus* were bought in

An Phu Farm – Hoc Mon District. Earthworms used for experiments were randomly picked from this source.

2.2 Experimental design

Plastic containers of 26.0 x 16.5 x 8.5 cm in volume were used to contain 20g of earthworms. Each treatment was triplicated and had 100g of feed mixture with different ratios of TS (75%, 50% and 25%). The control groups having the same ratio of feed mixtures but no presence of earthworms were introduced to every treatment. Feed mixtures were turned over frequently on 2 days period to avoid volatile toxic substances and ensure complete digestion. The containers were kept in darkness, 27 – 30°C temperature and 50 – 60% moisture by sprinkling water daily. After 30 days, earthworms and feed mixtures were collected separately from the containers to proceed to further analyses. Separation process was based on the method mentioned by Appelhof (1993).

2.3 Chemical analysis

Samples of final feed mixtures were drawn from the containers and pretreated according to ISO 11464:2006 “Soil quality - Pretreatment of samples” for chemical analysis. Homogenized samples then were obtained and sorted in airtight plastic bags for further analysis. Chemicals used were analytical reagent (AR) at 95% purity and above. All analyses were triplicated and the final results were averaged. The pH was analyzed according to Watson and Brown procedure (Dahnke, 1998), using pH meter. TKN was determined after digesting the

samples with concentrated acid sulfuric and acid salicylic (40:1, v/w) based on method of Cope (1916), using Kjeldahl digestion and distillation machines. TP was determined using the colorimetric method using Bray and Kurtz P-1 soil test method with ascorbic acid as reagents (Dahnke, 1998). Cr content was determined by Method 3051A of US EPA, carried out by the Quality Assurance and Testing Center 3. Moisture content of the sample was measured using gravimetric soil moisture method. Azotobacter bacteria were isolated from initial and final samples of the study, and counted using method in study of Tepper *et al.* (1979).

2.4 Statistical Analysis: SPSS statistical program was employed for data analysis. One-way ANOVA test was performed to determine variance differences between studied treatments, while a Turkey’s t-test was used to check homogeneity within data sets.

3. RESULTS

3.1 Main chemical characteristics of initial feed mixtures

From the chemical contents **Table 1** below, different chemical parameters analyses of the initial feed treatments were singled out. The initial pH values were in the acidic range (4.54 – 5.32), in which Treatment A (TS 75%) and B (TS 50%) were more acidic than C (TS 20%). TKN and TP content increased with the decrease of TS ratio in the treatments, but it was observed that the increase of TKN in Treatment C was greater than in Treatment A and B. Cr content was in the range of 5.10–10.0 mg/kg.

Table 1: Chemical contents (mg/kg) in the initial and the final period of different treatments (Mean± S.D.) (Numbers in “*” were given by the Quality Assurance and Testing Center 3)

Treatment	TS (%)	pH		TKN		TP		Cr*	
		initial	final	initial	final	initial	final	initial	final
A	75	4.54±0.06a	5.52±0.45a	1203.90±0.20a	3749.20±0.27a	0.47±0.28a	3.22±0.99a	10.00*	22.70*
B	50	4.77±0.04b	6.53±0.06b	1601.60±0.38ab	6506.50±0.16b	2.84±0.99b	18.94±3.18b	7.48*	22.54*
C	25	5.32±0.06c	6.98±0.11b	2883.40±0.94b	7546.00±0.29b	5.41±0.31c	11.21±1.08c	5.10*	14.05*

Means in the same column at initial and final period followed by the same letter are not significantly different ($p>0.05$)

3.2 Growth of *Perionyx ecavatus* in different feed mixtures

The mean biomass in all final treatments

were reduced significantly ($p<0.05$). The highest final biomass was observed in Treatment C (17.45g) and the lowest biomass in Treatment A

(4.85g). Final biomass in treatment B was 14.49g. The raise of TS ratio in the treatments stimulated a gradual drop in biomass of *P. excavatus*.

3.3 Changes of chemical characteristics of the final feed mixtures

Overall, pH increased, but still remained in the range of acidic and closer to neutral pH (5.52–6.98), while TKN and TP content also inclined. The raise in TKN was between 3749.20 mg/kg and 7546.00 mg/kg, in which content of TKN in final Treatment C was the highest and doubled the amount in control

Treatment C (**Figure 1**). Besides, TKN content in all control treatments was observed to be higher than initial but lower than final treatments. Similarly, from **Figure 1**, it could be concluded that both TP content in final and control treatments were higher than initial ones. Nonetheless, the increasing gap between final and control treatments was wider than the one between control and initial treatments. In final treatments, the maximum in TP content belonged to Treatment B and the minimum was with Treatment A.

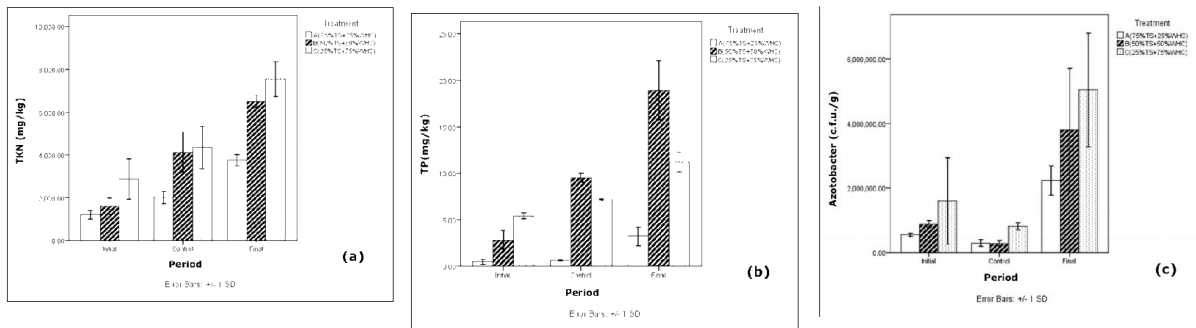


Figure 1: Changes in TKN content (a), TP content (b) and Azotobacter colonies count (c) in different treatments during various time periods of this study. (Error bars: +/- 1 S.D.)

Changes in microbial population

In summary, during vermicomposting process, the number of Azotobacter bacteria colony count increased. However, control treatments only rose slightly than initial treatments, while final treatments escalated above the two, from 2.53×10^6 in treatment A to 5.20×10^6 c.f.u./g in Treatment B.

Changes in Cr content

Chromium (Cr) content in various treatments were observed to overall increase after 30 days

in this study. Initially, Cr was highest in Treatment A (10.00 mg/kg) and lowest in Treatment C (5.10 mg/kg). Concentration of Cr in control treatments was only observed on the 8th day of the experiment, however, it all rose above the initial values at the 1st day. One important point here was the the Cr content in the control of Treatment C had increased significantly up to the value of 12.30 mg/kg, and reached near the mark of the final value at the 30th day, 14.50 mg/kg (Figure 2).

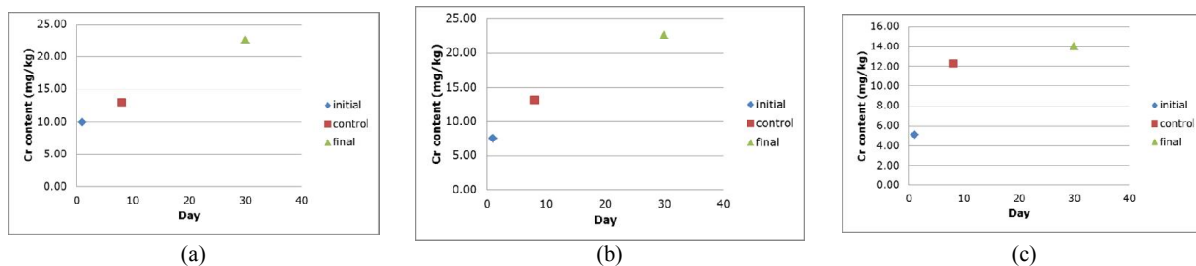


Figure 2: Changes in Cr content in a) Treatment A, b) Treatment B and c) Treatment C during various time periods of this study

4. DISCUSSION

Decrease in total biomass of earthworm implied mortality was observed in all treatments during the study period. Previous studies by Chan and Griffiths (1988) also reported death of earthworms fed with untreated pig dung, and Elvira *et al.* (1996) stated that paper-pulp sludge inhibited survival of worms. Both researches then attributed such mortality to environmental characteristic changes which stemmed from degradation process. This study also observed an incline in mortality with higher textile sludge content. Therefore, the degradation process of textile sludge in this case most likely resulted in the death of earthworms. In addition, water hyacinth vermicomposting with earthworm mortality was observed by Gupta *et al.*, (2007). Similarly, a study by Zibres *et al.* (2011) mentioned that feed mixture with a higher percentage than 50% of water hyacinth resulted in earthworms mortality. Furthermore, Edwards (1988) showed that feed mixtures must have enough easily metabolizable organic matter and nonassimilated carbohydrates to support earthworm growth and reproduction, and also stated that ones with high quantity of CWH were not sufficient in the above-mentioned factors. The data in this study reflected the fact that CWH contained nearly double the amount of Cr compared to TS. Moreover, CWH was noted as an effective plant in accumulating heavy metals such as Pb, Hg, Zn, Co, Cd, and Cu (Buta *et al.*, 2011). Therefore, it was deduced that putting CWH through a degradation process would probably release accumulated heavy metals in the plants, which affect earthworm survival. In conclusion, mortality of earthworms in this study could be due to the degradation process of sludge and water hyacinth.

The changes in physical appearance observed in this study towards darker color and finer texture in the final state were also supported by Elvira *et al.* (1996) and Garg *et al.* (2005). Fayolle (1985) rationalized that organic matter in the feed mixture was homogenized and refined by the mechanism of earthworms eating

the feed and discarding vermicast afterwards. The traces of untransformed sludge left in the final treatments suggested incomplete breaking down process by earthworms' mechanism.

pH in all treatments at the end of the study in the range of 5.5 to 7.0 (Table 1), which was in the range of acidic to moderately acidic. Soil pH close to neutral (6.5 - 7.5) was considered to be ideal as within this range, most plant nutrients were available to plants, and plant root growth was in favor (Jensen, 2010). The fact that pH in the final product increases testified an exudation of ammonia from nitrogenous matter which then released more available nitrogen in the soil (Vasanthi *et al.*, 2012). In addition, Ndegwa *et al.* (2000) also noted that bioconversion of organic matters resulted in intermediate species of organic acids, and different feedings could lead to different intermediate species thus expressing different pH shifts.

Also, the increase in soil acidic condition could be due to the mineralization process of nitrogen and phosphorous (Garg *et al.*, 2006), which led to a similar raise in TKN and TP content in all treatments. Total N in final treatments ranged from 0.3% to 0.75% which could be considered adequate owing to the fact that in dairy manure, total N would be ranging from 0.6-2.1% (Shukla and Chandel, 1989). According Crawford (1983), the final TKN content is most probably relied on two factors, the degree of decomposition and the TKN content in initial feeds. The former rests on the microbial population while the latter is subordinated to the proportion of microbial growth retarding materials contained in the proportion of industrial wastes in it (Suthar, 2010). One of them is the nitrogen-fixing bacteria, *Azotobacter*, whose increasing trend observed in the final treatments (Figure 1) acted as an indicator of indirect microbial effect onto the gain of TKN. Furthermore, a statistic significantly difference between final and control treatments ($p < 0.05$) affirmed that earthworms played a role in nitrogen level in soil. Earthworms is considered to add nitrogen

rich materials such as excreta, enzymes and mucus which changes the microclimatic conditions as well as moistens the body surface of feed mixtures (Singh and Suthar, 2012). Regarding TP increase in this study, Satchell and Martin (1984) confirmed this discovery finding a development of 25% in TP of vermicomposted paper waste sludge. They reasoned that this increase in TP was directly related to enzymes secreted by earthworms and indirectly stimulated by microbial actions. None the less, according to Shukla and Chandel (1989), the TP values obtained in the final products in this study (0.0003220-0.001894%) were below the range of dairy manure (0.7-1.1%). The exceptional increase of TP in the final Treatment B most probably be owing to the activities of unexplored microbial populations in this study.

The promotion in chemical values in feed mixtures certified the high level of vermicomposition, which further rationalized the growth in *Azotobacter* population. Between all initial and control treatments there was no significant difference ($p > 0.05$), while the incline in final treatments population count was significantly different ($p < 0.05$). Consequently, earthworms was believed to play an important role in promoting microbial population expansion. It was also noted by Edwards and Burrows (1988) that the number of fungi, bacteria, and actinomycetes was greater in vermicompost compared to the soil. In this particular experiment, the presence of sludge could also be one of the factors that inhibited *Azotobacter* population development. Besides, population count of *Azotobacter* in vermicompost end product is considered to be higher than those in other biofertilizers (Chitrapriya *et al.*, 2013). As a result, they believed vermicompost could improve soil fertility, and was a more natural fertilizer compared to chemical fertilizers and other biofertilizers.

The increase in Cr content in final products of this study was also noticed by previous researches. Elvira *et al.* (1996) reported in their study that total metal matters in vermicompost

were higher than in initial substrates while Kumar *et al.* (2008) also noted that Cr content during their study was found to be higher in vermicompost end product than in earthworms. One plausible explanation could be that the rate of bioaccumulation uptake by earthworms was lower than that of aerobic composting process of sludge which heightened level of Cr content. The fact that the increase in Cr concentration in the control group in this study was observed to increase approximately as high as the group with earthworms also agreed with this hypothesis. Moreover, Zheng *et al.* (2007) stated in that composting reduced the ratios of exchangeable, carbonate-bound, and organic matter-bound Cr while raised up the concentration of residual Cr. They also confirmed in their study that organic matter bound and residual Cr were not considered to be available to plants, hence composted products were better stabilized.

5. CONCLUSION

This study illustrated vermicomposting process as both a management method for waste textile sludge mixed with water hyacinth and an approach to obtain an valuable agronomic product. The addition of textile sludge in feed mixtures reduced worm biomass, but rising pH and nutrients contents (TKN, TP, nitrogen-fixing bacteria count). However, Cr was found leached during vermicomposting. Such phenomenon could be contributed to the decomposition of organic matters releasing organic acids, and earthworms' extractants as well as their bioconversion mechanism in the feed mixture.

To further enhance earthworms abilities to breakdown sludge structure, pretreatment of sludge should be considered. Besides drying in the open air, sludge could be put through composting from 1 to 2 months in prior of an experiment. Although the end products showed fertilizer values in terms of TKN, other parameters such as TP, other macronutrients and micronutrients contents in the end products were in the need for further research. Only be then, their fertilizer potentials and influences on plants could be completely understood.

Furthermore, the length of the study should also be better considered to allow better bioaccumulation process in earthworms to absorb heavy metals.

REFERENCES

- [1]. Appelhof, M. (1993). *Worms Eat Our Garbage: Classroom Activities for a Better Environment*. Flower Press, 10332 Shaver Road, Kalamazoo, MI 49002.
- [2]. Bhalerao, N. A., Moghe, C. A., Bhavsar, R. S., & Kharat, R. B., (1997). Sludge management process – a review of its application to industrial sludges. *Indian Journal of Environment Protection*, 7, 535–541.
- [3]. Balan, D.S.L. & Monteiro, R.T.R (2001). Decolorization of textile indigo dye by ligninolytic fungi. *Journal of Biotechnology*, 89, 141-145.
- [4]. Bray, R. H., & Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. *Soil science*, 59(1), 39-46.
- [5]. Buta, E., Paulette, L., Mihăiescu, T., Buta, M., & Cantor, M. (2011). The Influence of Heavy Metals on Growth and Development of *Eichhornia crassipes* Species, Cultivated in Contaminated Water. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 39(2).
- [6]. Chitrapriya, K., Asokan, S., & Nagarajan, R. (2013) Estimating the Level of Phosphate Solubilising Bacteria and *Azotobacter* in the Vermicompost of *Eudrilus Eugeniae* and *Perionyx Excavatus* with Various Combinations of Cow-Dung and Saw-Dust.
- [7]. Cohen, J. B. (1920). *Practical organic chemistry*. Macmillan.
- [8]. Crawford, J. H. (1983). Review of composting. *Process Biochem*, 18, 14-15.
- [9]. Dahnke, W. C. (1988). Recommended chemical soil test procedures for the North Central Region. *Bulletin*, 499.
- [10]. Darwin, C. (1881). The formation of vegetable mould, through the action of worms. London: John Murray.
- [11]. Edwards, C. A., (1988). Breakdown of animal, vegetable and industrial organic wastes by earthworms. *Earthworms in Waste and Environmental Management*, SPB Academic Publishing, *The Hague*, pp. 21–31
- [12]. Edwards, C. A., & Burrows, I. (1988). Potential of earthworm composts as plant growth media. *Earthworms in waste and environmental management/edited by Clive A. Edwards and Edward F. Neuhauser*.
- [13]. Edwards C.A., Arancon N.Q., Sherman R.L. (2010), Vermiculture technology: earthworms, organic wastes, and environmental management. Boca Raton: CRC Press Taylor and Francis Group.
- [14]. Elvira C., Sampedro L., Benítez E., Nogales R., (1998). Vermicomposting of sludges from paper mill and dairy industries with *Eisenia andrei*: a pilot-scale study. *Biores. Technol.*, 63, 205–211.
- [15]. Fayolle, L. (1985). Valeur des ordures menageres comme milieu d'elevage pour *Eisenia fetida andrei* (Oligochaeta: Lumbricidae). *Revue d'ecologie et de biologie du sol*, 22(3), 353-366.
- [16]. Gajalakshmi, S., Ramasamy, E. V., & Abbasi, S. A. (2002). Vermicomposting of different forms of water hyacinth by the earthworm *Eudrilus eugeniae*, Kinberg. *Bioresource technology*, 82(2), 165-169.
- [17]. Garg, V. K., Kaushik, P., & Dilbaghi, N. (2006). Vermiconversion of wastewater sludge from textile mill mixed with anaerobically digested biogas plant slurry employing *Eisenia foetida*. *Ecotoxicology and environmental safety*, 65(3), 412-419.
- [18]. Gates G.E., (1972) Burmese earthworms. An introduction to the systematics and biology of megadrile oligochaetes with especial reference to South East Asia. *Trans Am Philos Soc*, 62, 1-326.

- [19]. Gupta, R., Mutiyar, P. K., Rawat, N. K., Saini, M. S., & Garg, V. K. (2007). Development of a water hyacinth based vermireactor using an epigeic earthworm *Eisenia foetida*. *Bioresource technology*, 98(13), 2605-2610
- [20]. Jensen, T. L. (2010). Soil pH and the Availability of Plant Nutrients. *IPNI Plant Nutrition Today, Fall*, (2).
- [21]. Kaushik, P., Garg, V. K., (2003). Vermicomposting of mixed solid textile mill sludge and cowdung with the epigeic earthworm *Eisenia foetida*. *Bioresource. Technol.*, 90, 311-316.
- [22]. Kumar, S., Sharma, V., Bhoyar, R. V., Bhattacharyya, J. K., & Chakrabarti, T. (2008). Effect of heavy metals on earthworm activities during vermicomposting of municipal solid waste. *Water Environment Research*, 80(2), 154-161.
- [23]. Ndegwa, P. M., Thompson, S. A., & Das, K. C. (2000). Effects of stocking density and feeding rate on vermicomposting of biosolids. *Bioresource Technology*, 71(1), 5-12.
- [24]. Singh, D., & Suthar, S. (2012). Vermicomposting of herbal pharmaceutical industry solid wastes. *Ecological Engineering*, 39, 1-6.
- [25]. Shukla, R. S., & Chandel, P. S. (1989). A Text book of Plant Ecology including Ethnobotany and Soil Science. *Chand & Company Ltd., New Delhi*.
- [26]. Suthar, S. (2007). Nutrient changes and biodynamics of epigeic earthworm *Perionyx excavatus* (Perrier) during recycling of some agriculture wastes. *Bioresource Technology*, 98(8), 1608-1614.
- [27]. Suthar, S., & Singh, S. (2008). Vermicomposting of domestic waste by using two epigeic earthworms (*Perionyx excavatus* and *Perionyx sansibaricus*). *Int. J. Environ. Sci. Tech*, 5(1), 99-106.
- [28]. Suthar, S. (2010). Recycling of agro-industrial sludge through vermitechnology. *Ecological Engineering*, 36(8), 1028-1036.
- [29]. Tepper EZ, Shilnikova VK, Pereverzev, GI (1979). Workshop on Microbiology. M. p. 216.
- [30]. Vasanthy, M., Seetha devi, G., Karthiga, A., & Susila, S. (2012). Bioconversion of fruit waste into vermicompost by employing *Eudrillus eugeniae* and *Eisenia foetida*. *International journal of plant, animal and environmental science*, 2(4), 245-252.
- [31]. Zheng, G. D., Gao, D., Chen, T. B., & Luo, W. (2007). Stabilization of nickel and Cr in sewage sludge during aerobic composting. *Journal of hazardous materials*, 142(1), 216-221.

Tóm tắt:

XỬ LÝ Bùn THẢI ĐỆT NHUỘM BẰNG QUÁ TRÌNH Ủ VỚI TRÙN PERIONYX EXCAVATUS

Nghiên cứu này đánh giá khả năng xử lý bùn thải dệt nhuộm bằng quá trình ủ sử dụng trùn *Perionyx excavatus*. Lục bình ủ hoai được thêm vào bùn để tăng các thông số dinh dưỡng cho quá trình. Nghiên cứu đánh giá các tỷ lệ phối trộn khác nhau giữa bùn thải và lục bình. Các bình phản ứng được đặt trong tối và kiểm soát độ ẩm trong khoảng 50 – 60%. pH, nito Kjeldalh, phospho tổng và nồng độ Chromium được đo ở đầu và cuối quá trình. Khả năng tái sử dụng sản phẩm làm phân bón hữu cơ được đánh giá thông qua các giá trị dinh dưỡng của sản phẩm.

Từ khóa: Bùn thải dệt nhuộm; lục bình; *Perionyx excavatus*

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