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ISSN: 2383-2568 *Quarterly of International Archives of Health Sciences 2015;2(3):133-138*

Effect of Vermifiltration on COD and Color Removal from Textile Factories' Waste Water

ARTICLE INFO

Article Type
Original Research

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How to cite this article
Rabbani D, Mahvi A.H, Gilasi H.R, Rasuli F. Effect of Vermifiltration on COD and Color Removal from Textile Factories' Waste Water. International Archives of Health Sciences. 2015;2(3):133-138.

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Article History
Received: June 25, 2015
Accepted: September 15, 2015
ePublished: September 22, 2015

ABSTRACT

Aims Textile industries are among the manufactures which produce the highly polluted waste water. The purpose of this research was to evaluate the effect of vermifiltration on COD and color removal from textile waste water.
Materials & Methods This experimental research was performed March to August 2014 in one of the textile factories of Kashan region, Iran. The glass cubic kits with- without Eisenia fetida were used to filter the waste water samples. Data was analyzed using Kruskal–Wallis and two-way analysis of variance in SPSS 19 statistical software.
Findings The mean of COD concentration in the raw waste water samples was 1324.24±757.01mg/l which was decreased to 598.22±349.33 and 831.32±445.19mg/l after the experimental and control kits usage, respectively ($p<0.001$). The mean of color intensity in raw waste water samples was 51.2±30.6% which was decreased to 27.8±15.0 and 27.4±15.1% ($p=0.635$) in experimental and control kits, respectively. There was a significant negative correlation between COD removal and hydraulic loads ($p<0.001$; $r=-0.804$) and a significant negative correlation between color removal and hydraulic loads ($p<0.001$; $r=-0.278$) in both experimental and control kits.
Conclusion The most important risk groups in our study were abattoir workers, butchers, housewives and students who handle infected animals.

Keywords Textile Industry; Waste Water; Oligochaeta; Color; Vermifiltration

CITATION LINKS

[1] Microbial decolouration of ... [2] Evaluation of industrial dyeing wastewater treatment with coagulants and polyelectrolyte as ... [3] Integrated biological and ozone treatment of printing textile ... [4] Dye removal, energy consumption and operating cost of electrocoagulation of textile wastewater as ... [5] Comparison of physico-chemical, advanced oxidation and biological techniques for the textile wastewater ... [6] Study of photochemical and sonochemical processes efficiency for degradation of dyes in ... [7] Comparative study of oxidation of some azo dyes by different advanced oxidation processes: Fenton, Fenton-like, photo-Fenton and ... [8] Decolorization of a dye industry effluent by ... [9] Decolorization of practical textile industry effluents by white rot fungus ... [10] Studies on decolorization of reactive blue 19 textile dye by ... [11] Enzymatic treatment and detoxification of ... [12] Textile dyeing wastewater ... [13] Mineralization and discoloration of ... [14] Color removal and COD reduction of ... [15] Degradation of a textile reactive azo dye by a combined ... [16] Application of immobilized horseradish peroxidase for removal and detoxification of ... [17] Photocatalytic degradation of azo dye in aqueous TiO 2 suspension: Reaction pathway and identification of ... [18] Antibacterial and enzymatic activity of microbial community during wastewater treatment by ... [19] Biodecolorization of textile dyes by ... [20] Urban wastewater treatment using vermi-biofiltration system ... [21] Properties of biofilm in ... [22] Sewage treatment by vermifiltration with synchronous treatment of sludge by earthworms: a low-cost sustainable ... [23] Influence of bioaugmentation on biodegradation of ... [24] Removal of high BOD and COD loadings of primary liquid waste products from dairy industry by ... [25] Performance evaluation of vermifilter at different hydraulic loading rate using river bed ... [26] Treatment performance of small-scale vermifilter for ... [27] Laboratory scale studies on domestic grey water through ... [28] Vermistabilization of wastewater sludge from ... [29] Tertiary treatment of textile wastewater with ... [30] A study on hydraulic loading rate and worm density in ... [31] The treatment of ... [32] Wastwater treatment using vermifiltration technique at institutional ...

Introduction

Textile industries are among the manufactures which produce the highly polluted waste water; the pollution that have been considered as significant environmental problem for recent decades [1]. Large consumption of water and complexity of chemical substances usage in textile products processing, leads to environmental pollution in this industry [2]. Water demand in textile industries has been estimated 100-200liters per kilogram of products [3]. Consequently, recovery and reuse of waste water after employing appropriate treatment methods in arid area, especially Kashan, is very important [4].

High concentration of dying agents, Total Dissolved Solids (TDS) and Chemical Oxygen Demand (COD) and also, high potential of toxic substances presence are the major problems associated with textile waste water [5]. The removal of dye from effluents is one of the most significant environmental problems [6]. Although synthetic dies make our world more beautiful and their application are in growth, but due to their carcinogenic and toxicity nature, they are serious threat to the environment [7]. Today more than 10,000 types of dying agents and pigments are used in textile industries around the world which estimated to be about 800,000 tons per year, 10-15% of those (nearly 280,000 tons per year) are being released into the environment through waste water [8-10]. 60-70% of more than 10,000 dyes used in the textile industry are Azo dyes [11] that cause serious damages to soil and water sources by raw or insufficient treated waste water.

High level of COD, BOD5 (5-Day Biological Oxygen Demand), particles, oil and grease in the water bodies lead to oxygen deficit that have adverse effects on ecosystem [12]. Textile and other industrial dyes form one of the crucial organic compounds that cause an increase in environmental dangers [13]. Low concentrations (less than 1ppm) of dyes in waste water and water is highly demanded due to their undesirable effects on environment and horrible damages to nature of receiving bodies and also lowering the sun light penetration into the water sources which decrease the photosynthesis activities [6, 14, 15]. Synthetic dyes are very stable and resistant to microbial attack and therefore it is difficult to remove them from effluents by conventional biological processes [16], but about 45 to 47% of dying agents are biodegradable [17]. Physical and chemical methods such as coagulation-flocculation, advanced oxidation, and electrochemical processes are effective on color reduction, but due to the hardness of operation and high cost of needed chemicals and also production of complex sludge, they are not applied universally [5]. Therefore, searching for a low-cost, environment friendly and socially acceptable alternative waste water treatment processes are necessary [18].

Today biological processes have received more attentions because of their simplicity in application and less costs [19]. Earthworms were first applied by Toha in Chili University, in 1992, for waste water and sludge treatment, so called vermifiltration [20, 21]. Earthworms use waste water as their energy source and are adaptable to contaminated environments and facilitate growth of useful bacteria involved in waste water decomposing [22]. They also stimulate and increase microbial activity by creating the favorable conditions for bacteria and improving soil aeration. The earthworm has been found to eliminate up to 90% of BOD5, 80-90% of COD and up to 90-95% of TSS from waste water by ingestion mechanism, shell absorption and biological decomposition of biomaterials, heavy metals and solids [23]. This process is odorless and remains no sludge. Effluent from this process is suitable for parks and gardens irrigation because of its clarity [24]. Some other advantages of this process include needing less space and needless of pumping devices [25, 26]. *Eisenia fetida*, *Eisenia andrei*, *Perionyx excavatus*, *Eudrilus eugeniae* and *Lumbricus rubellus* are the best type of worms for purification purposes [22, 27].

As there are no studies of this method to remove COD and color form textile waste water, the purpose of this research was to evaluate the effect of vermifiltration on COD and color removal from textile waste water.

Materials & Methods

This experimental research was performed from March to August in one of the textile factories of Kashan region, Iran. 3 grab raw waste water samples were taken from the place by one month intervals and each raw waste water samples was divided into 36 proportions (each 1l) and was filtered separately through 2 kinds of glass cubic kits (experimental and control).

About 330g of *Eisenia fetida* was used in making the experimental filters. *Eisenia fetida* was selected because it produces more cocoons and is more adoptable to biomaterials and tolerate a wide range of pH, temperature and moisture and had been applied in some previous researches [28, 29]. During a month the worms were adopted to the industrial waste water by gradually increasing the concentration. The glass cubic kits were prepared in 17×17×100cm^3 dimensions by 4 different layers. The kits contained about30-40kg of gravels with a layer of soil on top which formed the vermifilter bed. The bottom most layer was made of gravel aggregates (7.5cm) and it fills up 25cm. Above this lied the aggregates of 3.5-4.5cm filling up to another 25cm. On the top of this was 10cm layer of aggregates of 10-12mm mixed with sand. The top most layer was about 20cm consisted of soil in which the earthworms were released. Different hydraulic loads (0.2, 0.35, 0.5 and 0.8m^{3}m^{-2}d^{-1}) were applied to them continuously. The difference between 2 kits was the presence of *Eisenia fetida* in the experimental kit and its absence in the control kit (Figure 1).

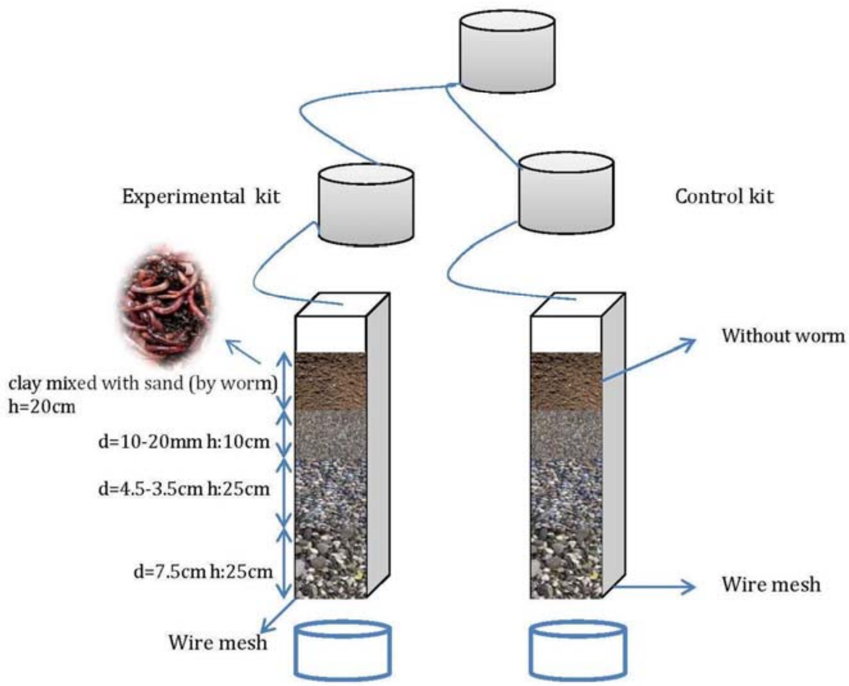

Figure 1) A scheme of the vermifiltration kits

The experiments were done at 21±3C° and 70% soil moisture in 4 hours detention time. The COD and color levels were measured before and after using the kits in both groups of samples. COD level was measured according to 5220-C method and color removal was calculated by 2120-C method using the spectrophotometer model PD-303UV (APEL; USA) [23].

Data was analyzed using Kruskal–Wallis and two-way analysis of variance in SPSS 19 statistical software.

Findings

The mean of COD concentration in the raw waste water samples was 1324.24±757.01mg/l which was decreased to 598.22±349.33 and 831.32±445.19mg/l after the experimental and control kits usage, respectively ($p<0.001$). The mean of color intensity in raw waste water samples was 51.2±30.6% which was decreased to 27.8±15.0 and 27.4±15.1% ($p=0.635$) in experimental and control kits, respectively (Figure 2).

There was a significant negative correlation between COD removal and hydraulic loads ($p>0.001$; $r=-0.804$) in both experimental and control kits. The maximum COD removal was 70% which obtained in the experimental kit effluent with $0.2 m^3 m^{-2} d^{-1}$ hydraulic load (Figure 3A). There was a significant negative correlation between color removal and hydraulic loads ($p<0.001$; $r=-0.278$) in both experimental and control kits (Figure 3B).

Figure 2) COD residual and color removal percentage in the different hydraulic loads in the experimental and control kits effluent

Hydraulic Loads ($m^3 m^{-2} d^{-1}$)	**Raw**	**Control kit**	**Experimental kit**
COD residual (mg/l)			
0.2 (n=9)	1517.38±1093.05	735.82±459.01	449.96±337.80
0.35 (n=9)	1311.40±676.20	745.93±360.87	478.84±253.66
0.5 (n=9)	1301.94±677.60	862.76±444.76	619.57±329.82
0.8 (n=9)	1242.28± 589.40	1020.80±484.30	844.56±370.30
Total (n=36)	1343.24±757.01	841.32±445.19	598.22±349.33
Color intensity (%)			
0.2 (n=9)	52.7±31.5	22.7±16.0	21.5±16.7
0.35 (n=9)	51.1±32.2	27.6±15.8	27.4±15.5
0.5 (n=9)	51.6±31.9	28.8±15.5	28.0±15.1
0.8 (n=9)	51.4±31.8	31.3±15.3	31.2±15.0
Total (n=36)	51.2±30.6	27.8±15.0	27.4±15.1

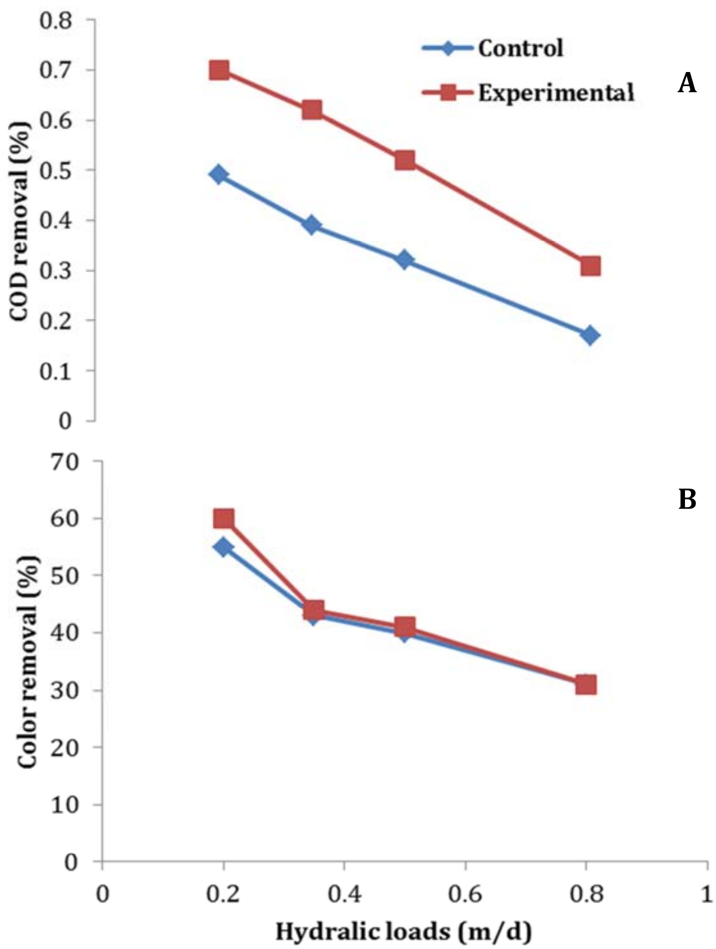

Figure 3) comparing the COD removal (A) and color removal (B) efficiency in the experimental and control kits in different hydraulic loads

Discussion

This study was designed to examine the effect of vermifiltration on color and COD removal from textile waste water. The results showed that as the hydraulic loads increased, less COD removal obtained in both the experimental and control kits. Such a change in removal efficiency is due to that, as the hydraulic loading increases, the hydraulic retention time in the kits decreases, so organic substances are not fully degraded before leaving the kits. This result is compatible with Sinha *et al.* [22] and Xing *et al.* [26]. Xing *et al.* have applied vermifiltration for sewage treatment in a pilot scale study and the COD removal was reported as 64.7 and 47.3% in 2.4 and $6.7 m^3 m^{-2} d^{-1}$ hydraulic loads, respectively [26].

The higher hydraulic load results in rinsing microbial layers from the filter media that may reduce the purification efficiency [29]. Malek *et al.*, have examined the effect of hydraulic loads and earthworm density in vermifiltration of palm oil factory waste water and have reported that by means of decreasing the hydraulic load and increasing the earthworm density, the COD removal was enhanced [30]. The earthworms produce some enzymes that are capable of decomposing chemical substances that are not decomposed by other microbes [25]. COD removal by earthworm kit was reported higher than 45% whereas by normal kit was 18% [22] which is not completely compatible with our results.

Taylor *et al.* have studied the treatment of domestic waste water using vermifilter beds and have concluded that worms can reduce BOD and COD loads more than 70-80% as well as the TDSS (total dissolved and suspended solids) significantly [31]. Lakshmi *et al.* have reported that reduction in concentration of BOD and COD in vermifiltered waste water compared with non-vermifiltered waste water [32]. According to color removing, our findings showed, same as COD removal, decreasing as the hydraulic loads increased. However, there was no significant difference between the color removal in earthworm and control kits. Such results probably are due to the fact that the rate of degradation of color agents is low [2].

As in this research no color removal by vermifiltration has found, we suggest revision of vermifiltration efficiency in combination with other treatment methods simultaneously and also vermifiltration efficiency evaluation to remove other pollutants from textile waste water.

Conclusion

Vermifiltration is an effective method for COD removal from textile waste water, while have not considerable effect on color removal.

Acknowledgments: Thanks to the great efforts of parents, teachers and all my colleagues who helped in the preparation of this study.

Ethical Permission: None declared by Authors.

Conflict of Interests: None declared by Authors.

Funding/Support: This work was supported by the Deputy of Research, Kashan University of Medical Science (Grant No. 92112).

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