Numerical analysis of textile industrial pollution: Case study of initial pollution dispersion into immediate environment

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Abstract. Pollution from textile industry is huge because the pollutants are chemical that are dangerous both in liquid and gaseous form. The dispersion of the pollutants was evaluated using mathematical models. It was observed that the dispersion modes of pollutants are both stable and turbulent. Hence, when textile pollution is not controlled, it has huge potential to claim life forms. It is recommended that the dumping and improper disposal of textile waste should be avoided. Also, there is an option of recycled or made from recyclable and biodegradable products.

1. Introduction
Food, clothing and shelter are the basic necessities of man. Hence, the textile and clothing industry serves the basic necessity: clothing. The clothing industry is expected to reach $700 billion. Presently it is worth $480 billion [1]. Recent surveys have shown that nearly 5% of all landfill spaces contains textile waste. Besides, 20% of all fresh water pollution is made by textile treatment and dyeing. The textile industry is one of the most prominent and largest industries of the world. Workers working in the textile industry are exposed to different types of chemicals. They are also exposed to some harmful metals like copper nickel and chromium. [2]

The prolonged exposure of these workers to pollutants (chemicals) can lead to series of diseases and health related issues like Cancer. Moreover, this chemicals used in the textile industry also harm the environment when they are not properly disposed. The non-biodegradability or slow biodegradable rate of these chemicals causes textile pollution.

The North Carolina death certificate shows that about 4,462 white females that died between1976-1978 worked previously in the textile industry. The numbers of the deceased were compared between cancer and other diseases. From the results it can be inferred that most of deceased female textile workers died as a result of cervical cancer whose cause can be traced back to the harmful chemicals that they were exposed to while they worked in the textile industry [3]. In April 2013, A Bangladesh textile supplying factory collapsed due to the carelessness of building specialist. Aside, the death from the collapsed building, there were pollution of the environment. Hundreds of textile workers were killed [4]. In September 2010, at least 289 people were killed in one of Pakistan’s fire that occurred at a garment (textile factory) in Karachi [5].
This kind of pollution causes Leukemia, pneumonia, birth defects and immune system defects, Autism, cardiovascular diseases [6]. The causes of textile pollution includes: Some organic and inorganic substances like salts, dyes, detergents, starches, toxic organic chemicals, biocides and ionic metals in textile waste waters; Organo-chlorine based compounds, formaldehydes, azo dyes, preservatives, benzidine and polyphosphates found in waste waters. [7]; Presence of Sulphur, vat dyes, naphthalol; Presence of heavy metals like copper, nickel, arsenic, mercury and lead; Presence of non-biodegradable dyes. [7] includes: Dyes, solvents, finishing chemicals and metals like copper, chromium and nickel. [8]; Polyvinyl chloride; Chlorine bleach (chlorine dioxide); Dyeing agents like benzidine and toluidine; Toxic chemicals like formaldehyde, lead and mercury; Carbon monoxide; Ammonia [9]. Below are some of the microorganisms that can be contacted from textile pollution: Pseudomonas sp.; Achromobacter sp. (bacterial species); Aspergillus fumigates (fungal species); The total Heterotrophic Bacteria (THB) e.g. E coli; Salmonella typhi (typhoid fever) [7-9]

Kurt Kipka, senior project manager at the natural resources defense council is of the view that “the figures can vary among sources and type of environmental impact, but it is clear that the textile industry is among the top five polluting global industries” [10]. Dorel Paraschiv, Cristiana Tudor and RaduPetrai from the International Business and Economics Department, Bucharest University of Economics Studies are of the views that any action that will be taken to aid sustainable development will have to include measures against all forms of pollution to help reduce pollution. He also said that some European countries in the textile industry are working towards a more sustainable industrial sector. [11]. Punyasloka et al. [12] in their article on “a review of the sustainability of textile industries wastewater and without treatment methodologies” are of the view that the textile industries in India play a vital role in the economic role of the nation. The textile industries in India generate enormous quantity of waste. Dr.VenkateshJaganathan, an associate professor of Anna University in India and his colleagues in a paper on environmental pollution risk in the textile industry are of the opinion that, in order to protect the environment, there should be a regular checking and filing of regulations that are related to a safe work place. Karthik T and Gopalakrishnan D. are of the opinion that people are searching for green products and the textile industry is making use of ecofriendly products that has led to the enactment of some rules on the textile industry especially in India [13].

2. Methodology
From existing literatures, little is known on the mathematics of the pollution in textile industry. Hence, the model adopted for this study was obtained from the WASD model [14]. WASDM is typically known as a model used for the pollutant dispersion in uniquely complex cases (equation 1). The assumption in the model is that pollutant dispersion occurs uniformly within a three dimensional space. This assumption may not hold in extremely turbulent cases. In very turbulent cases [15], the pollutants achieve an
enhanced flow in the z-direction. The pollutants transport in the z-direction enhances fast pollutant dispersion.

In this study, we assume turbulence dispersion of textile pollutants in air or waterways by considering only one-dimensional perspective. Hence, equation (1) was reduced to equation (3) on the assumption that the parameters ‘P’ and ‘S’ are equal to zero.

\[
\frac{\partial C}{\partial t} + V_x \frac{\partial C}{\partial x} - V_z \frac{\partial C}{\partial z} - V_y \frac{\partial C}{\partial y} = \frac{\partial}{\partial z} \left( K_z \frac{\partial C}{\partial z} \right) + \frac{\partial}{\partial y} \left( K_y \frac{\partial C}{\partial y} \right) + \frac{\partial}{\partial y} \left( K_{yz} \frac{\partial C}{\partial y} \right) - P + S
\]

\[\alpha \frac{C^2}{\partial x^2} + \beta \frac{C^2}{\partial y^2} + \gamma n z^{n-1} \frac{\partial C}{\partial z} + \gamma z^n \frac{\partial^2 C}{\partial z^2} = 0.\]

The solution of equation (3) was carried out using numerical analysis via C++ programming codes.

3. Results and Discussion

The solution of equation 3 is displayed in Figure 2. The first scenario (Figure 2a) is the pollutant dispersion is expected to be linear and can rise up to 90 g/m³.
Figure 2: Pollutant dispersion in a textile industry
The initial dispersion from the textile industry is turbulent. Then the pollutants attain a stable state (Figure 2b). The form of pollutant dispersion as presented in Figure 2c-I has two type of dispersion i.e. turbulent and stable. However, the dispersion at source is adjudged to be the highest. The comparative analysis of pollutants from two-dimensional perspective (Figure 2j) further affirm that pollutant dispersion is both stable and turbulent depending on the topography of the pollution site. The results imply that the dynamics of pollution from textile industry is complex and may go out of control if not adequately monitored.

4. Conclusion
Theoretical solutions to the problems of textile pollution have shown that the mode of pollutant dispersion is both turbulent and stable. It is recommended that there should be safety training for the workers on the dangers of the chemical pollution from the textile industry. Textile industries should be encouraged to make use to of eco-friendly products. Environmental Management System (EMS) should be employed as a procedure that ensures that the processes that are carried out in the textile industry are within international standards and they pose no threat to the environment. Based on the above findings, it is recommended that the dumping and improper disposal of textile waste should be avoided; rather the exportation of textile waste for reprocessing and reuse should be encouraged. The products are examined in terms of the impacts below. That they are recycled or made from recyclable and biodegradable products.

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