Analysis of Physicochemical Parameters in Wastewater and Heavy Metals in Soils of Flower Farms in Ethiopia

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Abstract— *Floriculture is a young and fast-growing industry in Ethiopia. The sector has created employment opportunity and contributed to our country's economic development. But it is blamed for causing environmental pollution. Therefore, the aim of this study is to determine the concentration of pollutants in wastewater and soils of flower farms located in Ethiopia which were selected using purposive sampling. Wastewater and soil samples required for the determination of physico-chemical parameters and heavy metal concentrations were collected from the flower farms from April 1 to May 25, 2019. Physicochemical parameters including pH, electrical conductivity, total dissolved solids, phosphate, sulfate and chemical oxygen demand in wastewater, and concentrations of lead, cobalt, and zinc in soil were determined. Accordingly, the pH values of the four flower farms (Farm 1, Farm 2, Farm 4 and Farm 5) were slightly acidic and below minimum pH value (6) allowed for wastewater effluent set by Ethiopian Environmental Protection Authority. Electrical conductivity at all farms, total dissolved solid at Farm 4, chemical oxygen demand at Farm 3, and 4, sulphate at Farm 4, and phosphate at Farm 2 and 4 were above the provisional standard set by EPA. This study revealed that wastewater sample collected from Farm 4 doesn't comply with EPA standard in all study parameters. While, the mean concentrations of cobalt and zinc of soil samples varied from 2.8 to 46.6 mg/kg and 54.4 to 111.1 mg/kg, respectively. Conclusively, the wastewater quality discharged from flower farms is not at a level it cannot cause harmful effect. Therefore, there is a need to ensure that wastewater is properly treated before discharged into the environment. Also, the authors recommend that further holistic investigation should be carried out on socio-economic and soil pollution of the floriculture industry in Ethiopia.*

Keywords— Floriculture, Heavy metal, Physicochemical, Soil, Wastewater.

I. INTRODUCTION

Floriculture is a discipline of horticulture concerned with the cultivation of flowering and ornamental plants for gardens and for floristry, comprising the floral industry. It can also be defined as "The segment of horticulture concerned with commercial production, marketing, and sale of bedding plants, cut flowers, potted flowering plants, foliage plants, flower arrangements, and noncommercial home gardening" (Getu, 2009; Tilahun, 2013).

Floriculture is a young and fast-growing industry in Ethiopia. Since the industry is export-oriented, it serves to generate foreign exchange. According to Arefaynie (2009), the major factors that have contributed to the development of horticulture industry in Ethiopia include suitable climate, altitude, and availability of land, low labor costs and other favorable conditions. In 2002, there were only five floriculture farms in the country; however, by 2008, this number rose to more than a hundred (EHPEA, 2014)

The study conducted by Kassa (2017) stated that Ethiopian floriculture industries currently produce several flower species, including roses, gypsophila, hypericum, limonium, carnations, and chrysanthemum. Currently, Ethiopia is benefiting from this development through creating employment opportunity for unemployed citizens. In addition, the floriculture industry has given the country's export sector an alternative export commodity to the traditional predominant export of coffee.

However, there are a number of challenges that must be resolved to continue the development of the sector with the present rapid pace. Among the challenges is high consumption of different chemicals by the sector which can damage the environment through its discharge. According to Tamiru (2007), the production of flowers uses more than 300 chemicals

such as pesticides and growth regulators, which can kill useful organisms in the soil and disturb the biodiversity surrounding the flower farms. It is known that soil pollution can lead to water pollution if toxic chemicals leach into groundwater, or if contaminated runoff reaches streams, lakes, or oceans (Bolo and Brachet, 2010; FAO, 2017). Phosphorus fertilizers are among the sources of heavy metal inputs; and superphosphate fertilizers contain, in addition to nutrient elements, trace metal impurities like cadmium (Cd) and lead (Pb). Malidareh and his colloeges (2014) showed that fertilizers might contain heavy metals that can cause serious problems in water and soil. Therefore, the objective of this study was to assess the status of environmental pollutants in five flower farms located in Central Ethiopia by analyzing physico-chemical parameters in wastewater and selected heavy metals in soils.

II. MATERIALS AND METHODS

2.1 Study area

The study area consists of five flower farms which were coded as Farm 1, Farm 2, Farm 3, Farm 4 and Farm 5 (Figure 1) for the sake of confidentiality. The flower farms were purposely selected based on the magnitude of the social complaint reported by Oromia Environment, Forest, and Climate Change Authority. Farm 1 and Farm 2 are found in Woliso and Bacho Woreda, respectively, of Southwest Shewa zone. Farm 3 and Farm 4 are both found in Walmera Woreda of West Shewa Zone and Farm 5 is located in Adami Tulu Jido Kombolcha Woreda of East Shewa zone.

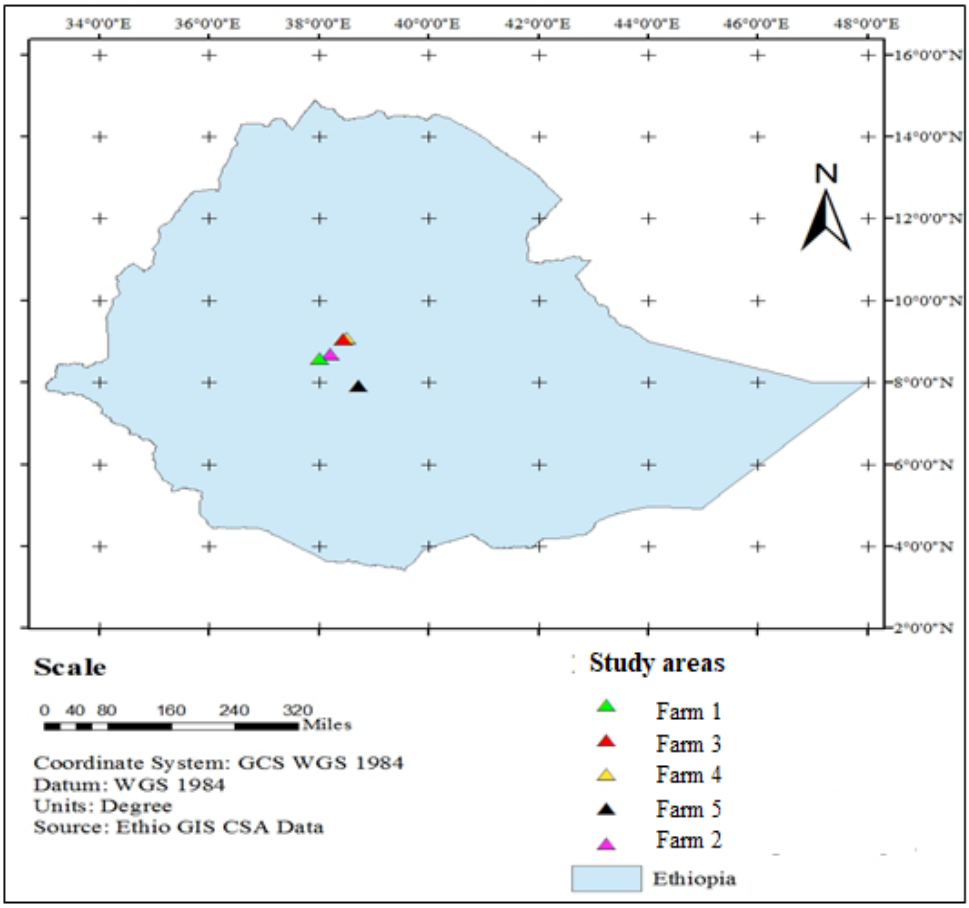

FIGURE 1: A map showing specific locations of the five flower farms

2.2 Sampling, sample handling, preparation and analysis

2.2.1 Wastewater sampling, handling, preparation and analysis

Wastewater samples were collected from five flower farms from April 1 to May 25, 2019. All samples were collected at the outlet in triplicate by using sealed plastic bottles which were thoroughly cleaned with detergent, rinsed with distilled water, soaked in 5% HNO_3^- for 24 hours and finally rinsed with distilled water. For each wastewater sample, pH, total dissolved solids (TDS) and electrical conductivity (EC) were measured at site using portable multi-meter (Jenway, model 3305). The remaining samples were labeled, preserved and transported to the laboratory in icebox. In the laboratory, the other parameters

were analyzed using standard methods (APHA, 2002) i.e. sulphate (SO_4^{2-}) by Turbidimetric, phosphate (PO_4^{3-}) by Vanadomolybdo phosphoric acid colorimetric, and chemical oxygen demand (COD) by the Open Reflux methods.

2.2.2 Soil sampling, handling, preparation and analysis

First, ten soil samples were collected from the top 30 cm depth of each farm using auger, spade and spoon, by applying random sampling technique. Then, ten soil sub samples of each flower farm were mixed, homogenized, placed into clean polyethylene bags in triplicate, labeled and transported to JIJE Analytical testing service laboratory P.L.C. in an icebox to avoid cross contamination and change of composition by weather conditions. In the laboratory, the samples were air dried and sieved to pass through 2 mm sieve, digested by microwave system and finally Pb, Co and Zn were analyzed by Flame Atomic Absorption Spectrophotometer (FAAS).

2.3 Statistical analysis

The data were analyzed by using Microsoft Excel 2010. Descriptive statistics were used to analyze the data obtained from physico-chemical analysis of wastewater and heavy metal concentrations of the soil samples.

III. RESULTS AND DISCUSSION

3.1 Physicochemical parameters for the wastewater

The mean pH value for each flower farm is shown in Table 1. The results indicated that the mean pH values of the four farms (Farm 1, Farm 2, Farm 4 and Farm 5) were slightly acidic and below minimum pH 6 which is allowed for wastewater effluent by Ethiopian Environmental Protection Authority (EPA, 2003). This may be associated to the addition of nitric acid and sulfuric acid to decrease the high pH of dripping water that arises from the use of fertilizers by the flower farms as stated by Tamiru and Leta (2017).

Wastewater with high amount of dissolved inorganic substances in ionized form could originate from fertilizers and pesticides used in flower farms. The mean EC values of wastewater were in the range 1,489.7- 17,546.6 μScm^{-1} (Table 1). The results obtained in this study were all higher than the optimum EC value of 1000 µS/cm for wastewater discharge set by EPA in 2003. High values of EC shows high inorganic ions in the wastewater (Aniyikaiye et al., 2019; Benit & Roslin, 2015). On other hand, the measured mean value of TDS in the wastewater samples of the flower farms varied from 1117.5 to 13160 mg/L. The TDS values of the selected farms were within the limit of provisional standard 3000 mg/L set by EPA except farm 4. The measured mean COD values of the studied flower farms' wastewater varied from 11.2 to 339.2 mg/L). The COD concentration was above permissible limit for Farm 3 and Farm 4 which could be attributed to excessive organic and inorganic chemical use in the flower farms. The results are presented in Table 1.

In this study the measured values of sulphate concentration are below provisional standard set by EPA (200 mg/L) except at Farm 4 (716.0 mg/L) which is above the limit. Similarly, the maximum phosphate concentration was detected at Farm 4 which was by far above EPA recommended value of 10 mg/L. The obtained maximum concentration of phosphate recorded might be due to the flower farm's high application of phosphate based fertilizers like ammonium phosphate. The result was shown in Table 1.

TABLE 1
PHYSICOCHEMICAL PARAMETERS IN WASTEWATER SAMPLES

Flower farms	Mean values of parameters					
	pH	EC(μScm^{-1})	TDS(mg/L)	COD(mg/L)	SO_4^{2-}(mg/L)	PO_4^{3-}(mg/L)
Farm 1	5.7	3116.9	2337.7	12.8	40	2.1
Farm 2	5.8	3120	2340.3	11.2	66	11.5
Farm 3	6.5	2683.6	2012.7	339.2	125.4	7.5
Farm 4	5.9	17546.6	13160	320	716	309
Farm 5	5.4	1489.7	1117.5	16	35.1	1
*EPA permissible limit	6-9	<1000	3000	250	200	10

Ethiopian Environment protection Authority (2003).

3.2 Heavy metal concentration of Soil samples

In this study, except for Farm 2 (12.4 mg/kg), the concentration of lead was below detection limit for all analyzed soil samples. The obtained result was within the EPA recommended value of 40 mg/kg (EPA, 2003). The mean concentrations of cobalt in soil samples taken from the flower farms were between 2.8-46.6 mg/kg (Table 2). The results revealed that the concentration of zinc was highest among the heavy metals analyzed from all the sample sites. The obtained values were below provisional standard of 500 mg/L set by EPA (2003). The low concentration level detected for soil analysis might be attributed to the washing of the soil by runoff, dispersion by air, and infiltration below soil sampling depth.

TABLE 2
HEAVY METAL CONCENTRATION IN SOIL SAMPLES

Flower farms	Mean value of heavy metals in mg/kg		
	Pb	Co	Zn
Farm 1	12.4	37.1	105.2
Farm 2	ND	22.2	106.4
Farm 3	ND	46.6	111.1
Farm 4	ND	23.8	91.6
Farm 5	ND	2.8	54.4
EPA standard	40	-	500

ND= Not detected

IV. LIMITATION OF THE STUDY

Wastewater discharges and soil samples were taken only once and analyzed for few main physicochemical and heavy metal parameters. Hence, it cannot be generalized for broader flower farm pollution status. The parameters that were found to be above the standard limits could have been justified in a better way had there been additional information on the use of fertilizer and other chemicals, wastewater treatment employed and efficiency.

V. CONCLUSIONS AND RECOMMENDATIONS

This study revealed that wastewater discharged from most study flower farms has contaminant concentration not in accordance with permissible level. Among the physicochemical parameters investigated: pH (for Farm 1, 2, 4, and 5), electrical conductivity (for Farm 1 to 5), chemical oxygen demand (for Farm 3 and 4), and phosphate (for Farm 4) not comply with the levels recommended for wastewater discharge set by EPA. Conclusively, the wastewater quality discharged from flower farms is not at a level it cannot cause harmful effect on the environment.

It is inevitable that some amount of pesticides from flower farms can reach our primary concern i.e. human beings and cause undesired impacts. Hence, the flower farms should shift to organic farming which relies on natural methods to control pests and diseases such as crop rotations, composting, encouraging the natural predators of common pests, and developing healthy flowers that have a natural resistance to pests and diseases, so that the related risk can be reduced. And also there is a need to ensure that wastewater is properly treated before discharge into the environment. Adding to this, the author's recommend that further holistic investigation should be carried out on socio-economic and soil pollution status of the floriculture industry in Ethiopia.

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