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Physicochemical Quality of Pre-Harvest Vegetables Irrigated with Urban Wastewater in Mekelle and Southern Zones of Tigray Region, Ethiopia

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Abstract: The study was conducted to determine the physicochemical quality of pre-harvest vegetables irrigated with urban wastewater in Mekelle, Alamata and Maychew. Physicochemical parameters of irrigation water were examined *in-situ* while heavy metal in vegetables (Swisschard, Onion, Cabbage, Lettuce, Tomato, Beet root, Carrot and Green pepper) and urban wastewater were investigated using atomic absorption spectrophotometer (AA46) from November 2012 to May 2013. Present study revealed that the mean temperature, pH, EC and TDS of the wastewater used for irrigation in Mekelle was 43.29, 9.83, 994.39 and 345.46, respectively, followed by Maychew (29.62, 8.81, 854.22 and 298.00), while the lowest was recorded at 30.1, 8.33, 745.06 and 274.33 at Alamata. The contamination of Pb, Ni, Cr, Fe, Zn, Cu and Co in wastewater irrigated vegetables was 0.40, 0.55, 4.03, 905.12, 4.22, 1.074 and 0.67 mg/kg, respectively. Heavy metal contamination of water from the three locations ranged from 0.09-0.18 for Cu, 0.19-0.38 for Pb, 0.67-1.34 for Zn, 0.68-1.36 for Cr and 17.58-35.16 mg/L for Fe. The presences of heavy metal contamination above the detection limit calls for the proper disposal and / or recycling of domestic and industrial wastes.

Key words: Atomic Absorption Spectrophotometer · Heavy Metal · Physicochemical · Pre-Harvest Vegetables · Urban Wastewater

INTRODUCTION

The use of wastewater in irrigation is increasing owing to water scarcity, waste disposal problem and urbanization, which has significant negative influence on human health and environmental quality throughout the world [1]. Continuous irrigation of agricultural soil with sewage and wastewater contamination of pathogenic organisms, organic matter, oil, solids and heavy metal accumulation in the vegetables [1-5]. Heavy metals are present in vegetables and irrigation water as a consequence of human activities unmanaged utilization of herbicides, chemical fertilizers and manures in the catchment area of the irrigation water source [6-7]. The situation can seriously harm the health of the farmers, the traders and the people who consume these vegetables. The use of wastewater for irrigation has increased the contamination of Cd, Pb and Ni in the edible portion of vegetables, potentially causing health risk in the long term [8-9]. Heavy metals are very harmful and extremely toxic because of their non-biodegradable nature, long biological half-lives, their potential to accumulate in different body parts and of their solubility in water [10-13]. Human foetuses and small children are especially susceptible to Pd and Hg, which adversely affect the central nervous system, impacting the neurologic, psychomotor and intellectual development of the child [14]. To our knowledge there is limited information

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available regarding the physicochemical contamination of pre- harvest vegetables grown in waste water irrigated farms in Ethiopia. The aim of this study was to determine physicochemical contamination of different wastewater irrigated vegetables in Mekelle, Alamata and Maychew Tigray region.

MATERIALS AND METHODS

Field Survey and Sample Collection: Field surveys were conducted to determine physicochemical quality of vegetables irrigated with wastewater in three areas of Tigray regions *i.e.* Alamata, Maychew and Mekelle 2012 and 2013 during the long dry season (November-May). Physicochemical parameters such temperature, pH, TDS and EC were measured at the site of collection using Hanna waterproof meters (HI 991300). For the heavy metal analysis 48 pre-harvest vegetables and 13 waste water samples were collected from small scale farms, located along the wastewater drainage canal in Alamata, Maychew and Mekelle Tigray Region using sterile zipped plastic bags and 500-ml plastic bottles and then brought to laboratory. The vegetables and water samples were digested using 2ml of 0.1 M HNO_3 and analyzed using atomic absorption spectrophotometer (model AA46).

RESULTS

Physicochemical Characteristics of Wastewater Used in the Study Areas: The present study revealed that the mean temperature of wastewater under investigation varied between 29.62 to 43.29 °C. The values were higher than WHO standard of 40°C for discharged of wastewater into stream The mean pH value ranging from 8.33 to 9.83 in the wastewater, the mean pH values recorded for all the sampling point were above the WHO pH tolerance limit of between 6.00-9.00 for wastewater to be discharged into channel into stream. The mean conductivity values ranging from 745.06-994.39 µS/cm-^{3}. Conductivity value is a useful indicator of its salinity in the wastewater. However the values for all the samples under WHO [15 and 16] guideline values of 1000µScm-3 for the discharge of wastewater through channel into stream. Also the mean concentration of Total dissolved solid (TDS) ranges from 274.33 to 345.95mg/l (Table 1).

Generally waste water samples from Mekelle shows the highest concentration of physicochemical parameters followed by Maychew and Alamata.

Table 1: Mean value of physical parameters of water in Mekelle, Alamata and Maychew

	Physical parameters			
Sources	Temp (°C)	pH	EC (µS /cm^{-3})	TDS (mg/l)
Mekelle	43.29	9.83	994.39	345.95
Alamata	30.11	8.33	754.22	274.33
Maychew	29.62	8.81	845.06	298.00

pH = Power of hydrogen ion, EC = Electric Conductivity, TDS = Total Dissolved Substance.

Table 2: Concentration of heavy metals (mg/kg) in some vegetables under waste water irrigation

		Concentration of Heavy metals (mg/kg)						
No.	Vegetable type	Pb	Ni	Cr	Fe	Zn	Cu	Co
1	Swisschard	0.55	0.53	3.59	862.08	4.48	1.61	1.13
2	Cabbage	0.30	0.44	1.30	988.12	2.63	0.67	1.05
3	Onion	0.74	0.45	1.28	331.09	4.15	1.31	0.32
4	Lettuce	0.54	0.50	3.46	1003.43	7.51	1.56	0.96
5	Tomato	0.54	0.37	8.94	2568.00	4.54	0.31	0.26
6	Beet root	0.19	0.48	0.37	434.71	3.35	0.49	0.84
7	Carrot	0.13	0.73	3.47	663.14	3.97	1.84	0.55
8	Green pepper	0.22	0.92	9.85	390.39	3.14	0.80	0.26
	Mean	0.40	0.55	4.03	905.12	4.22	1.074	0.67
	*DET.LIM	0.02	0.03	0.02	0.02	0.05	0.01	0.01

*Detection limit.

Table 3: Contamination of heavy metals (mg/L) in waste water sources from study areas

Water source	Cu	Pb	Zn	Cr	Fe
Mekelle	0.18	0.38	1.34	1.36	35.16
Maychew	0.09	0.19	0.67	0.68	17.58
Alamata	0.09	0.19	0.67	0.68	17.58
Mean	0.12	0.25	0.89	0.91	23.44
*DET.LIM	0.01	0.01	0.05	0.02	0.02

*Detection limit.

Heavy Metal Concentration of Vegetable Samples: Values of all heavy metals analyzed i.e. Pb, Ni, Cr, Fe, Zn, Cu and Co (0.40, 0.55, 4.03, 905.12, 4.22, 1.074 and 0.67 mg/kg respectively), in vegetable samples were above the detection limits. The mean concentration of the heavy metals detected in the irrigation water and different vegetables are Fe > Zn > Cr> Cu> Co > Ni > Pb.

Heavy Metal Concentration of Irrigation Waste Water Samples: The contamination (mg/L) of heavy metals in waste water used for vegetable irrigation was highest for Fe followed by Cr, Zn, Pb and Cu. Mean heavy metal concentration of waste water from the three locations ranged from 0.09-0.18 for Cu, 0.19-0.38 for Pb, 0.67-1.34 for Zn, 0.68-1.36 for Cr and 17.58-35.16 mg/L for Fe.

DISCUSSION

The present result showed that all the waste water samples from sampling locations were contaminated with physicochemical parameters. The mean temperature, pH and TDS of the wastewater under investigation value ranging from (29.62 to 43.29°C, 8.33 to 9.83, 274.33 to 345.95mg respectively), which is above WHO standard for discharge of wastewater into watercourse [17]. In terms of temperature and pH water from all the three sources were unsuitable for plant growth and for that matter, for vegetable production. However; the mean conductivity values ranging from 745.0 to 794.39µS/cm are under the WHO guideline values of 1000µS/cm^3 for discharge of wastewater through channel into stream [17]. As a result showed high of heavy contamination were observed vegetables compared to different wastewater samples. Similarly the mean contamination of the heavy metals detected in different vegetables and waste water were Fe > Zn > Cr > Cu > Co > Ni > Pb. The analysis result revealed that all the sampled irrigation water source and vegetables across the three locations have contamination of heavy metals [18]. This may be due to increased number of industries, releasing of waste waters and other solid wastes from around irrigation water. Similar studies, irrigation water is from urban streams, downstream of industrial activities, elevated levels have been reported [19]. Heavy metals found in domestic, industrial and municipal waste discharges, can be hazardous (toxic) to consumers of vegetables and other produce cultivated using wastewater [19]. The vegetables cultivated with the wastewater may be considered as unsafe for consumption. Furthermore, the consumption of heavy metal-contaminated vegetables can seriously deplete some essential nutrients in the body causing a decrease in immunological defences, intrauterine growth retardation, impaired psycho-social behavior, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer.

CONCLUSIONS

Physicochemical quality analysis of pre-harvest vegetables irrigated with urban wastewater was conducted in three locations from Tigray region. The following conclusions were drawn from the current study; From the data collected from this study, the physicochemical parameters analysized in Mekelle, Alamata and Maychew showed high levels of all the parameters. The high concentration of heavy metals (Fe, Zn, Cr, Cu, Co, Ni and Pb) in the irrigated vegetables in the study area may due to the continuous usage of wastewater as the main irrigation water source and the resulting bioaccumulation by vegetables. Heavy metal contamination varied among the test vegetables, which reflect the differences in their uptake capabilities of the plants. All vegetables irrigated with wastewater were of great health concern; they contained unacceptably high heavy metals, levels above those recommended by WHO. Consumption of these vegetables with elevated levels of heavy metals may lead to high level of body accumulation causing related health disorders. Thus regular monitoring of heavy metal contamination in the vegetables grown at waste water irrigated area is necessary and consumption of contaminated vegetables should be avoided in order to reduce the health risk caused by taking the contaminated vegetables. Our results are of great important for farmers in particular; those with health challenges or compromised immune system therefore need to be cautious during irrigation to avoid infection. Responsible agencies should carry out public health education and aware the general public on the potential effects of disposal of waste and the potential health hazards associated with the consumption of vegetables cultivated with wastewater.

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