

Heavy metals in soil and vegetables grown with municipal wastewater in Lahore

A. Hamid^{1*}, A. Mushtaq¹, R. Nazir² and S. Asghar¹

¹Department of Environment Science, Kinnaird College for Women, 93 Jail Road, Lahore, Pakistan

²Applied Chemistry Research Centre, Pakistan Council for Scientific & Industrial Research (PCSIR) Laboratories, Ferozpur Road, Lahore 54600, Pakistan

Abstract

Heavy metals contamination of fruits and vegetables as a consequence of wastewater irrigation is most important concern today. Present study measures heavy metals concentration (Cr, Cu and Pb) in soil and vegetable samples collected from agriculture area around four major drains of Lahore (Hudiarra drain, BabuSabu drain, Chota Ravi drain and Kharak drain). Results show that concentration of Cu, Cr and Pb in soil samples were in compliance with WHO and EU standards, with an average of 2.221 ± 1.184 , 5.314 ± 1.0511 and 3.864 ± 1.6095 mg/kg respectively. Cu content in vegetables ranged from 0.4-18.9 mg/Kg (average of 4.11 ± 6.639 mg/kg), was within limits while Cr in Lady Finger, from Chota Ravi drain area, was 13.2 mg/Kg which is higher than permissible limit (2.4 mg/Kg). While Pb concentration in vegetables samples varied between 0.7 -8.1 mg/Kg (Mean 2.329 ± 2.592 mg/kg), which was also higher than the standard (0.3 mg/Kg).

Keywords: Heavy metals; Drains; Contamination; Soil; Vegetables

Introduction

Industrial and municipal wastewater application for agricultural produce contaminates soil and crops with heavy metals and subsequently poses risk to humans and animals. According to an estimate about 20 million hectares of land worldwide is utilizing wastewater for irrigation with 10% of the total world's population being dependent upon wastewater irrigated food (Corcoran *et al.*, 2010). Likewise, in Pakistan increased demand of food, coupled with scarcity of water, has compelled a greater reliance on use of wastewater for agriculture purposes, with only 2 % water undergoing some treatment before use in irrigation.

The Lahore district drainage system, comprising eight main and 75 tributary drains, has become ultimate disposal locations for industrial and municipal effluents. Two hundred and seventy one industrial units release an estimated 281.6 cusec untreated effluent into the irrigation canals and drains (IPD, 2008) which is ultimately released into River Ravi, within a stretch of nearly 65 km (WASA, 2007) with the consequence that River Ravi quality has been termed as detrimental for fish and other aquatic life propagation (Akhtar and Mohammad, 2012). Characterization of

wastewater samples of drains of Lahore indicates varied concentrations of important parameters of special concern as regards irrigation water quality (Hamid *et al.*, 2013). Earlier, Afzal *et al.* (2000) has carried out similar study to demonstrate the high pollution levels of Hudiarra drain. Discharge of untreated industrial effluents without treatment and its subsequent use in agriculture results in contamination of soil and vegetation and cause toxic effects on crops and vegetables imparting major detrimental impacts on human health. A large number of industries discharge heavy metals as a significant part of their effluents and wastes that enter into surface water sources with the consequence that their manifold; these pose severe impacts and persist in the ecosystem for years (Khattak, 2014). Metals like cadmium (Cd), mercury (Hg), cobalt (Co), lead (Pb), copper (Cu), nickel (Ni), chromium (Cr), and zinc (Zn) are recognized as metals of immediate concern (WHO, 2010). Estimates reveal that heavy metal pollution has produced adverse impacts on soil, fruits and vegetable quality and requires utmost attention (Abii and Okorie, 2011; Sobukola *et al.*, 2010; Sharma *et al.*, 2007; Ismail *et al.*, 2011; Khan *et al.*, 2008;

*Corresponding author e-mail: almas209@yahoo.com

Jimoh *et al.*, 2012; Nazemi, 2012; Perveen *et al.*, 2012; Tasrina *et al.*, 2015; Delbari and Kulkarni, 2013; Najam *et al.*, 2015). Vegetables are an important constituent of diet. Comparison of vegetables, fruits and other grain crops shows that heavy metals are largely accumulated in the edible parts of vegetables (Mapanda *et al.*, 2005). Vegetables absorb and store high quantity of these harmful metals and become source of health problems when ingested by humans and animals (Alam *et al.*, 2003; Sobukola *et al.*, 2010). Elevated concentrations of Cd, Cu, Co and Pb in food stuff are basis of diseases such as bone cancer, high prevalence of upper intestinal cancer, reproductive effects, hypertension and renal failure (Turkdogan *et al.*, 2003). Long term exposure with these toxic elements, even at insignificant levels, causes noxious effects for humans and other living beings. Being nonbiodegradable in nature, persistent in environment and potential bioaccumulation, these metals lead to severe hazards once these enter the bodies of living organisms (Shahid *et al.*, 2015a). Many reports suggest that the continued ingestion of food contaminated with heavy metals can damage liver, nervous, cardiovascular, kidney and/or causing cancers (Jarup, 2003). Extensive evidence of health hazards due to intake of vegetables grown in sewage irrigated water has been reported (Avci, 2012; Ghosh *et al.*, 2012; Wang *et al.*, 2012; Weldegebriel *et al.*, 2012; Xue *et al.*, 2012). Iqbal *et al.* (2016) carried out a study in Pakistan to assess the concentrations of heavy metals in irrigation water, soil and vegetables, their transfer factors and human health risk. Similar study was conducted by Khan *et al.* (2013) to evaluate heavy metals in and around Lahore district and analysis revealed that metal concentration were higher when compared with WHO applicable limits. Similarly, Hamid *et al.* (2016) studied heavy metal contamination of vegetables and soil of Ruhidrain area and their likely health hazards and concluded that Pb Cd, Fe, Cu, Zn and Cr were found in higher concentrations in selected samples.

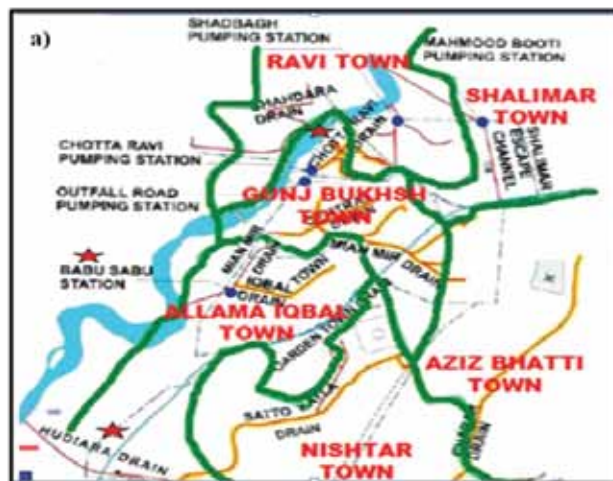
In view of the present issue of contamination of food, the current study was designed to determine the concentration of selected heavy metals (Cu, Cr, and Pb) in soil and vegetables that were cultivated by using waste water of major drains of Lahore city.

Materials and methods

Sampling locations

Four major drains of Lahore were selected. These included Babu Sabu drain (74.250001667, 31.5205556), Hudiara drain (74.350195278, 31.3835308), Chota Ravi (74.296235,

31.605436) and Kharak drain (74.256196, 31.51328). Soil (top soil TS, subsoil SS) and vegetable samples (being grown there) were collected from each site. Figure 1 (a,b) illustrates the sampling locations.



Source: Irrigation and power department, 2008



Source: Google Earth map

Fig. 1. (a,b) Map of the Lahore drainage and study area locations

Collection of vegetables and soil samples

Six different vegetable samples, which included bottle gourd (*Lagenaria siceraria*), spinach (*Spinacia oleracea*), egg plant (*Solanum melongena*), lady finger (*Abelmoschus esculentus*), pilak (locally grown vegetation/ a type of fodder), tomato (*Solanum lycopersicum*), and soil samples

(top soil and sub soil) were collected from selected drains, following sampling protocols and great care to avoid any kind of contamination (Ramteke *et al.*, 2016). Clean air tight plastic bags were used for the collection of these soil and vegetables samples.

Soil sample preparation

100g of each collected soil sample (TS, SS) was first air dried followed by oven drying at 120°C for 3-4 hrs. 10g of each dried soil sample was digested using 50 ml of aqua regia solution. The samples' solution were heated to boiling and allowed to simmer for 5-6 hr. After cooling, samples were filtered using Whatman 1 filter paper. After washing twice with 5 ml distilled water, the filtrate along with washings was transferred to 50 ml measuring flask. The volume of filtrate was made up to mark (Ramteke *et al.*, 2016) and solutions were analyzed for Cu, Cr and Pb (USEPA Method 3050).

Vegetable samples preparation

Six different types of vegetable samples were collected from the fields cultivated with drains' wastewater. The vegetables were washed with distilled water, air dried and chopped into small pieces. Approximately 80-100g of these chopped air dried vegetable samples were taken in petri dishes and oven-dried at 70°C for 3-4hrs. The dried vegetables were then transferred to beaker and digested with 50 ml of aqua regia solution. The samples' solution were heated to boiling and allowed to simmer for 1-2 hr followed by filtration using Whatman 1 filter paper. In each case, the filter paper was washed twice with 5 ml distilled water and the filtrate along with washings was transferred to 50 ml measuring flask (Taghipour and Mosaferi, 2013; Ramteke *et al.*, 2016). The volume of filtrate was made up to mark and solutions were analyzed to measure concentrations of Cu, Cr and Pb using atomic absorption spectrophotometer (Buck Model 210 VGP).

Results and discussion

The average results of metal analysis of soil and vegetable samples are given in Tables I and II respectively. Statistical analysis (maximum, minimum, mean value and standard deviation) for heavy metals concentration in vegetables and soil samples was also calculated (Table III).

A total of 7 (TS and SS) samples were analyzed and found to be within the limits (Table I). It is obvious that the concentration of Cu, Cr and Pb were meeting European

Union and WHO's allowed concentrations for metals in soil. This is similar to other studies carried out at Rawalpindi and Peshawar in which heavy metal concentration in soil was also

Table I. Heavy metals concentration in soil samples

Area	Soil Sample	Cu mg/Kg	Cr mg/Kg	Pb mg/Kg
BabuSabu Drain	TS	2.3	4.6	4.9
	SS	4.8	6.7	6.9
Hudiarra Drain	TS	1.95	6	1.95
	SS	1.3	5.6	3.4
Chota Ravi Drain	SS	1.5	4.3	3.4
	TS	2.0	6.1	2.8
Kharak Drain	TS	1.7	3.9	3.7
	Safe Limits	*140	*150	*300
		**100		**84

TS= top soil, SS =sub soil

*EU (2002), **WHO (2006)

Table II. Heavy metals concentration in vegetables grown by using irrigation water of drains and their comparison with WHO/FAO standards

Area	Sample No.	Vegetable Sample	Cu mg/Kg	Cr mg/Kg	Pb mg/Kg
BabuSabu Drain	1	Spinach	0.6	0.6	1.0
	2	Egg plant	1.2	1.2	1.6
	3	Bottle gourd	0.4	1.7	1.0
Hudiarra Drain	4	Tomato	1.3	1.4	0.7
	5	Lady finger	4.1	13.2	8.1
Chota Ravi Drain	6	Lady finger	2.3	1.7	1.9
	7	Pilak	18.9	0.8	2.0
		*WHO/FAO,	40	2.3	0.05-0.3
		**EU standards			

* WHO/FAO (2007),**EU (2006)

found to be within safe limits (Latif *et al.*, 2008; Perveen *et al.*, 2012). Lahore soil samples in another study (Khan *et al.*, 2013) showed Cu and Pb concentrations in soil in the range of 1.06-5.42 mg/kg and 2.11-36.88 mg/kg respectively. Although concentrations of Cu, Cr and Pb were below the

Table III. Statistical analysis for heavy metal concentration in the vegetable and soil samples (mg/kg)

Heavy Metals	Vegetable Samples			Soil Samples		
	Maximum value	Minimum value	Mean \pm SD	Maximum value	Minimum value	Mean \pm SD
Cu	18.9	0.4	4.11 \pm 6.639	4.8	1.3	2.221 \pm 1.184
Cr	13.2	0.6	2.943 \pm 4.542	6.7	3.9	5.314 \pm 1.0511
Pb	8.1	0.7	2.329 \pm 2.592	6.9	1.95	3.864 \pm 1.6095

limits, these metals are uptaken to different extent by different plants and are translocated to vegetables and fruits grown in that area. Wastewater use for irrigational purposes is reported to cause heavy metal magnification in plants i.e. heavy metals goes to plants without retaining in soil (Achakzai *et al.*, 2011).

From the results of vegetable samples analysis (Table II), it is observed that concentration of Cu ranged from 0.4 - 18.9 mg/Kg with Mean \pm SD value 4.11 \pm 6.639mg/ kg which was within safe limit (40 mg/Kg) of EU (2006), in all vegetables samples. Chromium concentration in vegetables ranged from 0.6 - 13.2 mg/Kg (Average 2.943 \pm 4.542 mg/kg) and was exceeding the permissible levels given by WHO/FAO and EU (2.3 mg/kg). The maximum chromium content (13.2 mg/Kg) was found in lady finger plant grown at Chota Ravi drain area; other plants such as eggplant, tomato, spinach and pilak also had trace amounts of metals but very high level of chromium in lady finger would be due to absorption capacity and ability of the plant. Chromium absorbs rapidly in soil but retain there for short interval because it goes to the other medium such as plants. Oliveira (2012) reported that the level of heavy metal concentration vary with parts of the plant as most of the plants have higher quantity of heavy metals in roots and stems; however their quantity lowers down in the leaves. Many studies in Pakistan have reported Cr in soil in permissible range of 100-150 mg/Kg with global mean soil concentration of 60 mg/Kg (Waseem *et al.*, 2014). While vegetables grown on soils irrigated with drain water showed Cr concentration above the tolerable ranges (Perveen *et al.*, 2012).

According to the results, Pb in vegetables samples varied between 0.7 - 8.1 mg/kg with mean 2.329 \pm 2.592 mg/kg. Lead levels in vegetables were also not in compliance with WHO/FAO and EU limits (0.05-0.3mg/Kg). This is in agreement with other study (Khan *et al.*, 2010) which reports Pb levels in vegetables in Gilgit, Pakistan in the range of

0.03-44 mg/Kg. Similarly, Farooq *et al.* (2008) also reports Pb concentration as 27.49 mg/kg and 15.58 mg/kg in edible and leafy parts of vegetables respectively, with 83% vegetable samples (edible part) contaminated with Pb content higher than EU (2006) limits.

The results of present study are also consistent with earlier study by Hamid *et al.* (2016) which also reported Cu, Cr and Pb at compliance levels in soil samples while elevated concentration were detected in selected vegetables.

Based on current study results, the trends of Cu, Cr and Pb in selected vegetables are as follows:

Cu = Pilak > Ladyfinger > Tomato > Eggplant > Spinach > Bottle gourd

Cr = Ladyfinger > Bottle gourd > Tomato > Eggplant > Pilak > Spinach

Pb = Ladyfinger > Pilak > egg plant > Bottle gourd = Spinach > Tomato

Conclusion

It can be concluded that vegetables grown along four major drains are contaminated with metals i.e. Cu, Cr and Pb in varying amounts. In soil samples Cu, Cr and Pb are detected but their concentration are within applicable permissible limits whereas concentration of Cr and Pb is high in vegetables samples. Application of wastewater for irrigation has the potential to accumulate high level of heavy metals in human due to consumption of these vegetables.

References

- Abii TA and Okorie DO (2011), Assessment of the level of heavy metals (Cu, Pb, Cd and Cr) contamination in four popular vegetables sold in urban and rural markets of Abia State Nigeria, Continental, *Journal Water Air and Soil pollution* 2(1): 42-47.

- Achakzai A, Bazai Z and Kayani S (2011), Accumulation of Heavy Metals by Lettuce (*Lactuca Sativa* L.) Irrigated with different levels of wastewater of Quetta City, Pak. *J. Bot.* **43**(6): 2953-2960.
- Afzal S, Ahmad I, Younas M, Zahid DM, Atique HMK, Ijaz A and Ali K (2000), Study of Water Quality of Hudiara Drain, India-Pakistan, *Environ Int.* **26**(1-2): 87-96.
- Akhtar S and Mohammad N (2012), Impact of Water Quality on Aquatic Life in River Ravi, Pakistan, *Journal of Nature Environment and Pollution Technology* **11**(2): 219-224.
- Alam MGM, Snow ET and Tanaka A (2003), Arsenic and heavy metal contamination of vegetables grown in Santa village, Bangladesh, *Sci. Total Environ.* **308**: 83-96.
- Avci H (2012), Trace metals in vegetables grown with municipal and industrial wastewaters, *Toxicological and Environmental Chemistry* **94**: 1125-1143.
- Chauhan G (2014), Toxicity study of metals contamination on vegetables grown in the vicinity of cement factory, *International Journal of Scientific and Research Publications* **4**(11): 1-8.
- Corcoran E, Nellemann C, Baker E, Bos R, Osborn D and Savelli H (2010), Sick Water? The central role of wastewater management in sustainable development, A Rapid Response Assessment, United Nations Environment Programme, UN-HABITAT, GRID-Arendal.
- Delbari SA and Kulkarni KD (2013), Determination of heavy metal pollution in vegetables grown along the roadside in Tehran– Iran, *Scholars Research Library Annals of Biological Research* **4**(2): 224-233.
- European Union (EU) (2002), Heavy Metals in Wastes, European Commission on Environment.
- European Union (EU) (2006), Commission regulation (EC) No. 1881/2006, setting maximum levels for certain contaminants in foodstuffs, *Official Journal of the European Union* **364**: 5-24.
- Farooq M, Anwar A and Rashid U (2008), Metal contents in vegetables grown on an Industrial area, *Pak J. Bot.* **40**(5): 2099-2106.
- Ghosh AK, Bhatt MA and Agrawal HP (2012), Effect of longterm application of treated sewage water on heavy metal accumulation in vegetables grown in Northern India, *Environmental Monitoring and Assessment* **184**: 1025-1036.
- Hamid A, Zeb M, Mehmood A, Akhtar S and Saif S (2013), Assessment of Wastewater Quality of Drains for Irrigation, *Journal of Environmental Protection* **4**: 937-945.
- Hamid A, Riaz H, Akhtar S and Ahmad RS (2016), Heavy Metal Contamination in Vegetables, Soil and Water and Potential Health Risk Assessment, *Am-Euras. J. Agric. & Environ. Sci.* **16**(4): 786-794.
- IPD (2008), An Atlas: Surface Water Industrial and Municipal Pollution in Punjab, Irrigation and Power Department, Directorate of Land Reclamation Punjab, pp 1-132.
- Iqbal HH, Taseer R, Anwar S, Mumtaz M and Shahid N (2016), Human health risk assessment: heavy metal contamination of vegetables in Bahawalpur, Pakistan, *Bulletin of Environmental Studies* **1**(1): 10-17.
- Ismail F, Anjum MR, MamonAN and Kazi TG (2011), Trace metal contents of vegetables and of Hyderabad Retail Market, *PJN* **10**(4): 365-372.
- Jarup L (2003), Hazards of heavy metal contamination, *British Medical Bulletin* **68**(1): 167-182.
- Jimoh TO, Ndamitso MM, AbdullahiSH and Bankole MT (2012), Determination of copper, iron and lead levels in selected vegetables obtained from the three main markets, in Minna, North Central Nigeria, *AJFS* **6**(23): 554-559.
- Khan A, Javid S, Muhmood A, Mjeed T, Niaz A and Majeed A(2013), Heavy metal status of soil and vegetables grown on peri-urban area of Lahore district, *Soil Environ.* **32**(1): 49-54.
- Khan S, Aijun L, Zhang S, Hu Q and Zhu YG (2008), Accumulation of polycyclic aromatic hydrocarbons and heavy metals in lettuce grown in the soils contaminated with long-term wastewater irrigation, *J. Hazard Mater.* **152**: 506-515.
- Khan S, Rehman S, Khan AZ, Khan MA and Shah MT (2010), Soil and vegetables enrichment with heavy metals from geological sources in Gilgit, Northern Pakistan, *Ecotox Environ Safe.* **73**(7): 1820-1827.
- Khattak IM (2014), Determination of heavy metals (Cu, Cd, Zn, Ni & Pb) levels in untreated waste effluents of industries in Quetta, *Sci. Int (Lahore)* **26**(1): 301-305.

- Latif MI, Lone MI and Khan KS (2008), Heavy metals contamination of different water sources, soils and vegetables in Rawalpindi area, *Soil & Environment* **27**(1): 29-35.
- Mapanda F, Mangwayana EN, Nyamangara J and Giller KE (2005), The effects of long-term irrigation using water on heavy metal contents of soils under vegetables, *Agri. Ecosys. Environ* **107**: 151-156.
- Najam S, Nawaz R, Ahmad S, Ehsan N, Khan MM and Nawaz HM (2015), Heavy Metals Contamination of Soils and Vegetables Irrigated with Municipal Wastewater: A Case Study of Faisalabad, *Journal of Environmental and Agricultural Sciences* **4**: 6-10.
- Nazemi S (2012), Concentration of Heavy metal in edible vegetables widely consumed in Shahroud, the North East of Iran, *J Appl Environ Biol Sci.* **2**(8): 386-391.
- Oliveira H (2012), Chromium as an Environmental Pollutant: Insights on Induced Plant Toxicity, *International Journal of Botany*, p 8.
- Perveen S, SamadA, Nazif W and Shah (2012), Impact of Sewage water on vegetables quality with respect to heavy metals in Peshawar, Pakistan, *Pak. J. Bot.* **44**(6): 1923-1931.
- Ramteke S, Sahu LB, Dahariya SN, Patel SK, Blazhev B and Matini L (2016), Heavy metal contamination of vegetables, *Journal of Environmental Protection* **7**: 996-1004.
- Shahid M, Dumat C, Pourrut B, Abbas G, Shahid N and Pinelli E (2015a), Role of metal speciation in lead-induced oxidative stress to *Vicia faba* roots, *Russian Journal of Plant Physiology* **62**(4): 448-454.
- Sharma KR, AgrawalM and Marshall F (2007), Heavy Metal Contamination of Soil and Vegetables in Suburban Areas of Varanasi, India, *Ecotoxicology and Environmental Safety* **66**(2): 258-266.
- Sobukola OP, Ademiran OM, Dairo AA and Kajihusa OE (2010), Heavy metal levels of some fruits and vegetables from selected markets in Lagos Nigeria, *African Journal of Food Science* **4**(2): 389-393.
- Taghipour H, Mosaferi M (2013), Heavy Metals in the Vegetables Collected from Production Sites, *Health Promotion Perspectives* **3**(2): 185-193.
- Tasrina RC, Rowshon A, Mustafizur AMR, Rafiqul I and Ali MP (2015), Heavy Metals Contamination in Vegetables and its Growing Soil, *J. Environ Anal Chem.* **2**: 142.
- Turkdogan MK, Fevzi K, Kazim K, Ilyas T and Ismail U (2003), Heavy metals in soil, vegetables and fruits in the endemic upper gastrointestinal cancer region of Turkey, *J. Environ. Toxicol. Pharmacol.* **13**: 75-179.
- Wang YC, Qiao M, Liu YX and Zhu YG (2012), Health risk assessment of heavy metals in soils and vegetables from wastewater irrigated area, Beijing-Tianjin city cluster, China, *Journal of Environmental Sciences-China* **24**: 690-698.
- WASA (2007), Presentation on the Initiative Taken in WASA Lahore Regarding Benchmarking of UWSS, Water and Sanitation Agency, Lahore.
- Waseem A, Arshad J, Iqbal F, Sajjad A, Mehmood Z and Murtaza G (2014), Pollution status of Pakistan: A retrospective review on heavy metal contamination of water, soil and vegetables, *Biomed. Res Int.* p 29.
- Weldegebriel Y, Chandravanshi BS and Wondimu T (2012), Concentration levels of metals in vegetables grown in soils irrigated with river water in Addis Ababa, Ethiopia, *Ecotoxicology and Environmental Safety* **77**: 57-63.
- WHO (2010), Guideline for drinking water Quality recommendation (Vol.1), World Health Organization, Geneva.
- WHO/FAO (2007), Joint FAO/WHO Food Standard Programme Codex Alimentarius Commission 13th Session, Report of the Thirty Eight Session of the Codex Committee on Food Hygiene, Houston, TX, USA.
- WHO (2006), Guidelines for the safe use of wastewater, excreta and greywater: Wastewater use in agriculture (Vol. II), World Health Organization, Geneva.
- Xue ZJ, Liu SQ, Liu YL and Yan YL (2012), Health risk assessment of heavy metals for edible parts of vegetables grown in sewage-irrigated soils in suburbs of Baoding City, China, *Environmental Monitoring and Assessment* **184**: 3503-3513.

Received: 24 January 2017; Revised: 21 March 2017;

Accepted: 29 May 2017.