Arsenic Research and Global Sustainability – Bhattacharya, Vahter, Jarsjö, Kumpiene, Ahmad, Sparrenbom, Jacks, Donselaar, Bundschuh & Naidu (Eds)
© 2016 Taylor & Francis Group, London, ISBN 978-1-138-02941-5

Continuous use of arsenic contaminated irrigation water: A future threat to sustainable agriculture in Pakistan

A. Javed[1,2], B. Afzal[2], I. Hussain[2] & A. Farooqi[2]

[1]*Department of Earth and Environmental Sciences, Bahria University, Islamabad, Pakistan*
[2]*Environmental Geochemistry Laboratory, Department of Environmental Sciences, Faculty of Biological Sciences, Quaid-i-Azam University, Islamabad, Pakistan*

ABSTRACT: Research work was conducted in Waziarabad District to investigate the concentrations of arsenic in irrigation water, soil and plant parts and to assess the future threat to the economy. The level of arsenic in irrigation water was much above the WHO permissible limit (0.01 mg/l) for drinking water, but within the FAO permissible limit of 0.10 mg/l for irrigation water. Results indicate that the arsenic is transferred from irrigation water and paddy soil to various parts of rice plants. In none of the studied samples the concentration of arsenic in soil and in rice exceeded the permissible limit (25 mg/kg for soil and 0.2 mg/kg for rice grain) which means that consumption of rice does not pose a significant health threat to population; however, the future projections of soil As possess threats to the economy of the country in future To avoid the future problems due to arsenic contamination, there is a need to take appropriate steps, such as development of new irrigation strategies and continuous monitoring of irrigation water, soil and grain.

1 INTRODUCTION

Arsenic (As) rich groundwater is used extensively for crop irrigation, particularly for the paddy rice which may result in yield reduction (Dittmar *et al.*, 2010). In Pakistan, rice meets more than 2 million ton of nation's food requirement and earns about US $ 933 annually from foreign exchange (Manzoor *et al.*, 2006). District Wazirabad is well-known for its high quality export rice where ground water is extensively used for irrigation. The main objective of this study was to investigate the concentrations of As in irrigation water, soil and plant parts, its distribution and mobility in the soil of a rice paddy and to assess the threat to the economy in coming years.

2 METHODS/EXPERIMENTAL

2.1 *Study area and sampling*

Wazirabad is situated on the bank of the Chenab Rivernearly 100 kilometers north of Lahore on the Grand Trunk Road. Samples of groundwater, soil, and rice were taken from agricultural land of five different villages, i.e, Dohnkal (Site A), Begowali (site B), Mansoorwali (Site C), Sohdra (Site D) and Ojlankalan (Site E) of Wazirabad. From each site, five shallow tube wells at depths ranging from ca. 20–50 m were selected as sampling points. 25 irrigation water samples (collected in pre-washed polyethylene 100 ml bottles), five composite soil samples (20–25 g at depth 0–25 cm were collected with the help of PVC pipe sampler), and five composite rice samples (total 25 samples collected in polyethylene bag), from each tube well and its surrounding cultivated land in 2014. The soil and plant samples were dried, stored at 4°C and transported to laboratory.

2.2 *Data analysis*

Hydride Generation (HG) AAS was used for the analysis of total As in all of the water and soil samples (detection limit 5 μg/L). Total As in rice plants were analyzed by ion hydride generator atomic absorption spectroscopy. The precision of the analysis was also checked by certified standard geological reference materials from Japan, such as JSD1 and JSD2 were used for the quality assurance of the results for As determinations in soil.

3 RESULTS AND DISCUSSION

3.1 *Arsenic in water, soil and plant parts*

Figure 1 shows the mean As concentration in water, soil, and different parts of plant. The results reveals that the mean As concentrations in the irrigation water are well within the FAO limits of 100 (μg/l) for irrigation water, however, the mean concentration of all water samples exceeds WHO limits of 10 μg/l for drinking water. Analysis of Irrigated rice paddy soil revealed that As concentration in soil was found to be in the range of 2.0–6.9 mg/kg, which was below the maximum acceptable limit for agricultural soil (25 mg/kg). The present study indicates that the

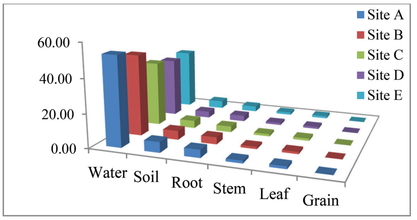

Figure 1. Mean concentration of As in water (µg/L), soil, root, stem, leaf and grain in mg/kg) in study area.

agricultural soil of the study area accumulate As due to excessive use of As contaminated irrigation water; this can been seen by high As concentration in irrigation water and soil in both Site A and Site B as compared to other sites (Fig. 1).

The total As in grain was found to have the following range; 0.001 to 0.06 mg/kg in grain, which is less than global normal distribution range of 0.08 to 0.20 mg/kg and is also lower as compared to Bengal of 0.028 to 0.961 mg/kg (Halder *et al.*, 2014) suggesting that population is not at risk by the direct consumption of rice.

3.2 *Arsenic transfer from water to soil and plant*

The correlation coefficients (r^2) among As concentrations in irrigation water, soil and in different parts (root, stem, leaf and grain) revealed that the As content of the soil is significantly correlated with the As content of irrigation water ($r = 0.582$). This indicates that the usage of As rich irrigation water in the study area have a potential to contaminate the agricultural soil with As. High significant correlation is obtained between As concentrations in irrigation water and root ($r = 0.601$). Thus from the results it can be concluded that the As contaminated irrigation water and the agricultural field soil are highly responsible for the transfer and uptake of As in rice plant. Moreover, As uptake by plant is also affected by the rice variety/grain size which is well demonstrated by Halder *et al.* (2012) who concluded that average accumulation of As in rice grain increases with decrease of grain size.

3.3 *Future threats to sustainable agriculture*

On basis of results of As in irrigation water and soil in present study we have assessed the potential effect of As concentrations in irrigation water on soils for the coming years up to 2045 using Linear regression model. A correlation factor of As addition to soil per 10 years was calculated from the study of Brammer & Revenscroft (2009). We have estimated an increase in soil As concentration for year 2035 (52.5 mg/kg) and for 2045 (147 mg/kg). Similar trend of increasing As in soil is reported by Dittmar *et al.* (2010) that As concentration top in paddy soil will increases by a factor of 1.5–2 by the year 2050.

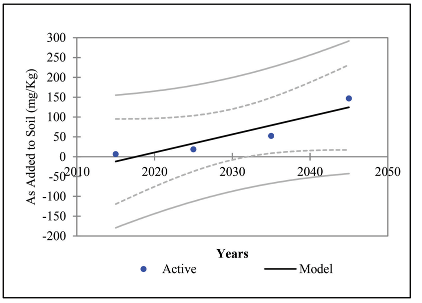

Figure 2. Regression of As added to soil (mg/kg) by year ($R^2 = 0.8534$).

Thus, future simulation of As in paddy soil poses a threat to the economy of the country in future.

4 CONCLUSIONS

The level of As in irrigation water, soil and grain of the study area were found to be with the permissible limits. Arsenic is transferred from irrigation water and paddy soil to various parts of rice plants. We also found that consumption of rice does not pose a significant health threat to population; however, the future projections of soil As possess threats to the economy of the country in future. To avoid the future disturbance due to As contamination, there is a need to take appropriate steps.

ACKNOWLEDGEMENTS

The author acknowledges the Geological Survey of Pakistan (GSP) for analytical facilities.

REFERENCES

Brammer, H., Ravenscroft, P. 2009. Arsenic in groundwater: a threat to sustainable agriculture in South and South-east Asia. *Environ. Internat*. 35(3): 647–654.

Dittmar, J., Voegelin, A., Roberts, L.C., Hug, S.J., Saha, G.C., Ali, M.A., Badruzzaman, A.B.M., Kretzschmar, R. 2010. Arsenic accumulation in a paddy field in Bangladesh: seasonal dynamics and trends over a three-year monitoring period. *Environ. Sci. Technol*. 44: 2925–2931.

Halder, D., Biswas, A., Slekjovec, Z., Chattarjee, D., Nriagu, J., Jacks, G., Bhattacharya, P. 2014. Arsenic species in raw and cooked rice: Implications for human health in rural Bengal. *Sci. Tot. Environ*. 497: 200–208.

Halder, D., Bhowmick, S., Biwas, A., Mandal, U., Nriagu, J., Guha Mazumder, D.N., Chatterjee, D., Bhattacharya, P. 2012. Consumption of brown rice: a potential pathway for exposure in rural Bengal. *Environ. Sci. Technol*. 46: 4142–4148.

Manzoor, Z., Awan, T. H., Zahid, M. A., & Faiz, F. A. 2006. Response of rice crop (super basmati) to different nitrogen levels. *J. Animal Plant Sci*. 16(1–2): 52–55.