

Arc GIS based Interpretation of Heavy Metals in Soil Samples near Coastal Areas of Badin, Sindh, Pakistan

Mohammad Amin Qureshi^{1*}, Muhammad Murtaza Qureshi², Munwar Saeed Qureshi³, Afzal Shah⁴

¹ Department of Agriculture Extension, Jamshoro, Sindh, Pakistan.

² Institute of Advanced Research Studies in Chemical Sciences, University of Sindh, Jamshoro, Pakistan.

³ Department of Chemistry, Government Degree College, Keamari, Karachi, Pakistan.

⁴ Department of Chemistry, University of Science and Technology, Bannu, Pakistan.

*Email: qureshamin@gmail.com

Received: 16 February, 2020

Accepted: 24 December, 2020

Abstract: This study was aimed to assess the severity of heavy metal contamination in eastern coastal area of Pakistan. Agriculture lands near district Badin coastal area found contaminated due to mega surface canal drain network, carrying untreated industrial and municipal effluents along with pumped saline water. Thirty-two random soil samples were collected from different coastal areas. Arc Geographic Information System was used for spatial mapping. Soil samples from coastal areas of Badin contain average concentrations of heavy metals (mg/kg) as Hg 0.247 ± 0.207 , Ni 2.622 ± 1.107 , Zn 3.121 ± 0.929 , Cu 0.059 ± 0.066 , Fe 70.447 ± 1.163 , Mn 7.062 ± 1.251 , Co 0.0167 ± 0.033 , Cr 0.799 ± 0.718 .

Keywords: Heavy metals, Badin coastal area, left bank outfall drain, GIS.

Introduction

Mineral components, organic matter and living organisms are the basic components of soil, which play very important role in the food chain. Heavy metals are natural constituents of the earth crust (Krishna and Govil, 2007). Contamination of heavy metals in soil is a problem throughout world. It is a significant toxicological risk to biological organisms (Zhang et al., 2014; Sharma et al., 2015; Moore et al., 2016). Heavy metals are non-degradable and capable of bioaccumulation, which are persistent in natural conditions (Zhang et al., 2010; Yan and Shengji, 2014; Hu et al., 2017). The deterioration of the environment due to heavy metal contamination has raised serious concerns. Sources of heavy metal pollution can be both natural and anthropogenic (Carr et al., 2008). The majority of the heavy metals are toxic to the living organism (Aslam et al., 2013; Reza et al., 2015). The soil heavy metals are of more concern because of longstanding toxicity to soil life (Liu et al., 2009). Mostly industrial waste effluents and domestic sludge are the sources of heavy metals and pollute the soil of nearby places (Kabir et al., 2010; Yan et al., 2013; Li-qun, 2015). Crops and vegetables sown through mine waste and industrial effluent water can produce high amount of metal pollution affecting the productivity of soil (Saif et al., 2005; Krishna and Govil, 2007; Halim et al., 2015; Zhou, et al., 2016).

The southern coastal district Badin, Sindh, Pakistan, connected with the Arabian Sea, is being polluted due to throwing of industrial and municipal liquid wastes by open canal drains known as Left Bank Outfall Drain (LBOD) (Memon et al., 2010). Besides seawater intrusion, increased groundwater table and frequent occurring cyclones and floods are major components deteriorating natural resources and disturbing

environmental and ecological phenomenon (Chaniho et al., 2010). Heavy metals concentration infiltrates into aquatic ecosystems from industrial and municipal wastewater discharge (Zubair et al., 2014; Anwar and Chandio, 2012). Badin coastal areas having some protected areas and very near to those areas, oil exploration activities may also be causing to pollution. The coastal area of this district provides a passageway for 4400 cusec drainage through LBOD for three decades contaminating agriculture lands, wetlands and protected areas; Ramsar recognized lagoons and coastal water. The present study was intended to evaluate the concentration status of heavy metal contamination in the soil samples collected from the near drainage networking areas of LBOD and areas linked with tidal water of coastal areas.

Materials and Methods

District Badin situated southern region of Sindh, between $24^{\circ}5'$ to $25^{\circ}25'$ north latitude and $68^{\circ}21'$ to $69^{\circ}20'$ east longitude. It has been bordered with the Arabian Sea and. Rann of Kutch, wild life sanctuary and protected area along with two Ramsar recognized wetlands. The main source of economy are agriculture and agro based industries. The coastal area of Badin district faces multidirectional natural and anthropogenic environmental problems (Fig.1). Coastal tidal lakes leave large amounts of salt when get dry, which spreads over agricultural lands through speedy winds during summer hot months, damaging the standing crops.

Soil samples of coastal area of district Badin were collected from 32 sampling points. The sampling location stations identified using a global positioning system (GPS). Composite sampling was done by selecting three sub samples randomly. Salt crust was

removed prior to sample collection in the month of April 2014. Soil samples were taken at a depth of 0-20 cm by using acid-washed spade. Though wheat crop has been harvested in nearby areas but soil samples were collected from the places which were either near left bank out fall drains or barren areas left fallow or areas hit by tidal waters of lagoons of the coastal region. All samples were stored in polyethylene bags and kept cool. Prior to analysis, samples were air-dried, roots and other recognizable plant materials were removed, grinded up to powder size and homogenized (Gupta, 2011).

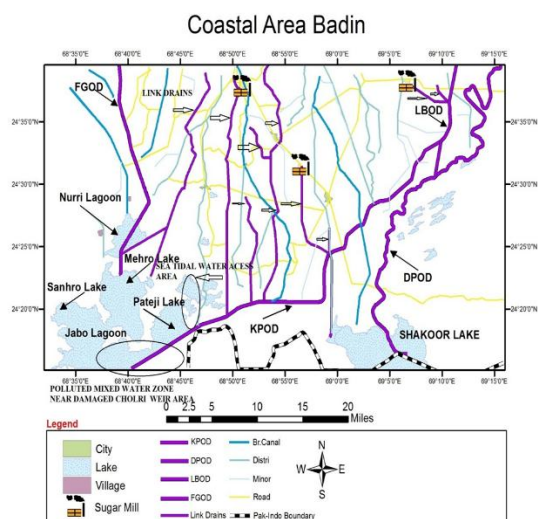


Fig. 1 Location map of the study area.

The air-dried soil samples in the ratio of 1:2 (v/w) retained in a shaker Orbital incubator (Model 14000, Irmeco GmbH Geesthacht Germany), with 100 rpm, for half an hour. The suspension was kept for a while to be settled. The pH and conductivity values were determined by pre calibrated Orion 420A pH meter and Orion 115 conductivity meter from the supernatant. However, strong acid digestion method ($\text{HNO}_3/\text{HClO}_4/\text{HF}$) was used for dissolution and separation of concentration heavy metals from soil sample. Calcium, cobalt, chromium, copper, iron, lead manganese, zinc, nickel, and mercury were determined using FASS (Gupta, 2011). Cold Vapour Atomic Absorption Spectrometric method was used for mercury (Hg) determination.

For displaying and mapping data, Arc GIS 9.2 software was used (Burrough, 1986; Gupta, 2011; Abbas et al., 2012). The GPS system was used for preparing a point featured map to locate and coordinate the sampling points. The obtained results were categorized into lowest, medium and highest using a color symbology scheme.

Results and Discussion

The results of concentration of mercury (Hg), represented with red color ranging from 0.082 to 1.22 mg/kg (Fig. 2). These ranges are characterized as a

default set by arc GIS mapping. Alarming high, mercury concentration is found at sampling station S-1, near depression area of DPOD (Dhoro Puran Outfall Drain). Average concentration of Hg is 0.247 mg/kg. In Pakistan, all the sectors of society and industry have exposure to mercury, which creates very critical situation. The total minimum emission and transfer of mercury in Pakistan is 10842 kg/year, which represents 637.76 mg per capita per year exposure of mercury (Abbas et al., 2012). Hg is a persistent, toxic and bio-accumulative heavy metal. Soil is considered enriched with Hg when the concentration is ≥ 0.100 mg/kg, while legislative limit for clean soils in the Dutch Guidelines is 0.3 mg/kg. Hg concentration greater than 1 mg/kg indicates that the corresponding soils may be potential health risks. Our findings of mercury are in agreement with a study over trace metals in soils of China showing mean range of mercury from 0.018 to 0.210 mg/kg (Cheng et al., 2014). Agricultural soils of Pakistan have less amount of mercury than the permissible limit 0.3 mg/kg. However, maximum mercury concentrations are present near the solid waste disposal sites in all provinces of Pakistan. In Pakistan, the potential source of Hg discharge in water and lands may be due to controlled landfills, thermometers and batteries in Pakistan (Ahmad and Erum, 2010). It is evident from the undertaken study that the soil samples near the drain network possess high concentration of Hg in coastal areas.

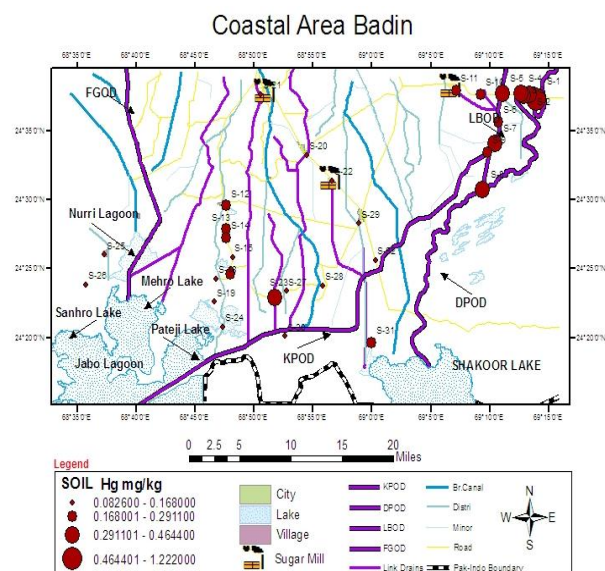


Fig. 2 Map showing concentration of mercury

The range of Ni concentration in coastal sampling areas is 1.462 to 5.092 mg/kg (Fig.3). The average concentration of Ni was found (2.622 mg/kg) alarmingly high. The findings of the undertaken study for Ni concentration in soils are in agreement with the available literature (MacLean et al., 1987; Zhang et al., 2010; Memon et al., 2010; Chanhio et al., 2010; Aslam et al., 2013; Ali et al., 2014).

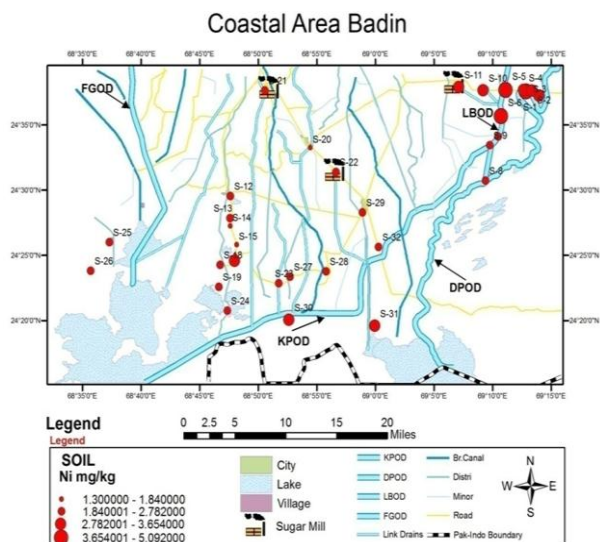


Fig. 3 Map showing concentration of Ni.

Whereas the results for zinc concentration, range from 1.38 to 5.06 mg/kg (Fig 4). High concentration of zinc is present near main LBOD drain. The average amount of Zn is 3.121 mg/kg. In a study, conducted near coastal area of Badin to assess the micronutrient status of soils, zinc was within the range 0.51 to 2.1 mg/kg (Memon et al., 2012).

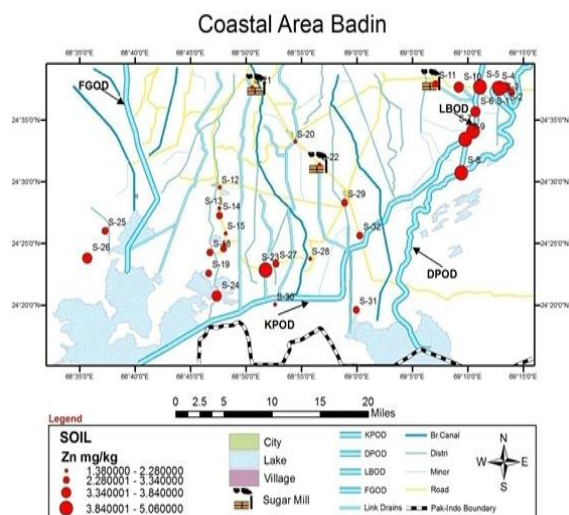


Fig. 4 Map showing the concentration of Zn.

Cu concentration ranges from 0.0284 to 0.227 mg/ kg at coastal areas (Fig. 5). The average amount of Cu is 0.059 mg/kg. In a study to assess the micronutrient status in the soils of Taluka Badin, Sindh, Cu concentration is reported in a range from 5.0 mg/kg to 6.9 mg/kg by Memon et al. (2012).

The results for the concentration of iron were observed from 68 to 70.7 mg/kg (Fig.6). The maximum concentration of iron ranges from 70.7 to 72.56 mg/kg. Iron concentration in all sampling stations is alarmingly high and the average concentration of Fe in these areas has been reported to range between 24-79 mg/kg by Memon et al. (2012).

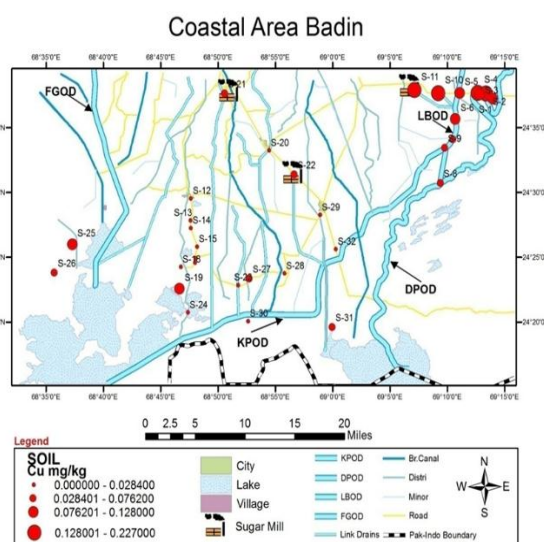


Fig. 5 Map showing concentration of Cu.

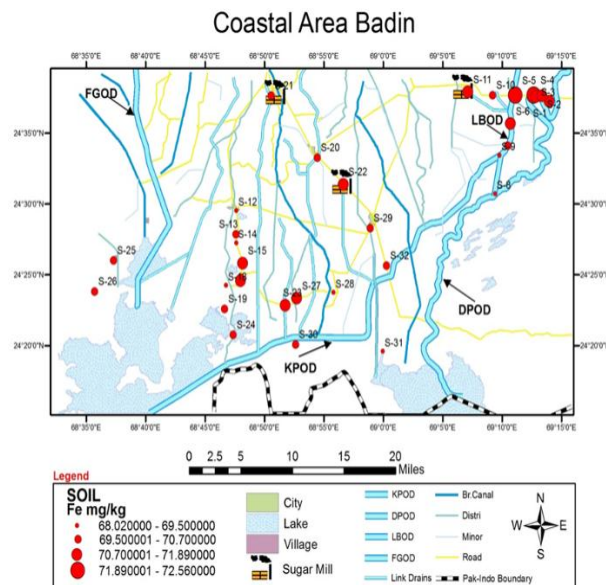


Fig. 6 Map showing concentration of Iron.

The results for manganese (Mn), concentration ranges from 5.2 to 6.3 mg/kg. Concentration of Mn is reported in a range of 8.8 to 22.3 mg/kg by Memon et al. (2012).Whereas the concentration of Cobalt (Co) ranges from 0.0134 to 0.144 mg/kg. Maximum amount of cobalt is found near the soil (S-6), which is very close to main LBOD drain. In literature, considerable amounts of 2.45 mg/kg and 0.45 mg/kg of Co are reported in soils of coastal areas of Egypt and industrial areas of Oman, (Al-Rashdi and Sulaiman, 2013). The chromium (Cr) concentration was found alarmingly high at different sample stations. Chromium was present within the range of 0.012 to 2.48 mg/kg. Sampling station S-31 possesses maximum concentration of chromium. The average amount of Cr was 0.799 mg/kg.

Conclusion

It was observed that soil samples taken from coastal areas of Badin were contaminated with heavy metals.

Main source for soil contamination is drainage network, which brings industrial and municipal effluent. Drainage water must be brought under regular observation according to environmental rules and regulations of Pakistan. Barren soils near drains and polluted wet lands are worst affected. As barren soils are devoid of cultivation since years, thus less possibility for heavy metals to be taken up by plants as a process of phytoremediation. Therefore, these fields must be brought under cultivation as well for tree plantation. Further, research on soil sediments, ground water and potable water of coastal regions is desirable.

References

- Abbas, Z., Chaudary, M.N., Raza, A., Mehmood, A. (2012). Toxicity of mercury in different samples (water and soil) and its exposure in Pakistan. *Science International*, **24** (4), 421-429.
- Ahmad, S.S., Erum, S. (2010). Integrated assessment of heavy metals Pollution along motorway M-2. *Soiland Environ.*, **29**(2), 110-116.
- Ali, S.M., Pervaiz, A., Beenish, A., Naima H., Azra, Y. (2014). Open dumping of municipal solid waste and its hazardous impacts on soil and vegetation diversity at waste dumping sites of Islamabad city. *J. K. Saud Univ. Sci.*, **26**, 59–65. doi.org/10.1016/j.jksus.2013.08.003.
- Al-Rashdi, T. T., Sulaiman, H. (2013). Bioconcentration of heavy metals in Alfalfa (*Medicago sativa*) from farm soils around Sohar Industrial area in Oman. *APCBEE Procedia*, **5**, 271-278. doi:10.1016/j.apcbee.2013.05.047.
- Anwar, M.M., Chandio, N.H. (2012). Impacts of drain water on soils and crops and it causes: A case study of Kamber Taluka, Pakistan. *Sindh University Resource Journal*, **44**(4), 623 -626.
- Aslam, J., Khan, S.A., Khan, S.H. (2013). Heavy metals contamination in roadside soil near different traffic signals in Dubai, United Arab Emirates. *Journal of Saudi Chemical Society*, **17**, 315–319.
- Burrough, P.A. (1986). Principles of geographic information system for land resources assessment monograph on soils and resources survey no.2 Clarendon Press Oxford, England
- Carr, R., Zhang, C., Moles, N., Harder, M. (2008). Identification and mapping of heavy metal pollution in soils of a sports ground in Galway City, Ireland, using a portable XRF analyser and GIS. *Environ. Geochem. Health*, **30**, 45–52
- Chaniho, H.B., Rajpar, I., Talpur, U.A., Sial, N.B., Zia-ul-hassan (2010). Evaluating soil and ground water in Taluka Tando Bago Sindh. *Pak. J. Agri., Agril. Engg., Vet. Sci.*, **26**(2), 19-26.
- Cheng, H., Li, M., Zhao, C., Li K., Peng, M., Qin, A., Cheng, X. (2014). Overview of trace metals in the urban soil of 31 metropolises in China. *J. Geochem. Explor.*, **139**, 31–52.
- Gupta, P. K. (2011). Methods in environmental analysis of water, soil and air. 2nd edition Agribios India.
- Halim, M. A., Majumder, R.K., Zaman, M.N., (2015). Paddy soil heavy metal contamination and uptake in rice plants from the adjacent area of Barapukuria coal mine, northwest Bangladesh, *Arab Journal Geosciences*, **8**, 3391-3401.
- Hu, B., Wang, J., Jin, B., Li, Y., Shi, Z. (2017). Assessment of the potential health risks of heavy metals in soils in a coastal industrial region of the Yangtze river delta. *Environment Science Pollution Resources*, **24**, 19816–19826
- Kabir, M., Iqbal, Z.M., Farooqi Z.R., Shafiq, M. (2010). Vegetation pattern and soil characteristics of the polluted industrial area of Karachi. *Pakistan Journal of Botany*, **42**(1), 661-678.
- Krishna, A.K., Govil, P.K. (2007). Soil contamination due to heavy metals from an industrial area of Surat, Gujarat, *Western India Environmental Monitoring Assessment*, **124**, 263–275
- Li-qun, C., Yeboah, S., Cheng-sheng, S., Xiao-dong, C., Zhang Ren-zhi. (2015). GIS-based assessment of arable layer pollution of copper (Cu), zinc (Zn) and lead (Pb) in Baiyindistrict of Gansu province. *Environmental Earth Sciences*, **74**, 803–811
- Liu, H., Li-Ping Chen, Ying-Wei Ai, Xia Yang, Yan-Hua Yu, Yuan-Bin Zuo, Guo-Yong Fu. (2009). Heavy metal contamination in soil alongside mountain railway in Sichuan, *China Environmental Monitoring Assessment*, **152**, 25–33.
- MacLean, K. S., Robinson A. R., MacConnell, H. M. (1987). The effect of sewage-sludge on the heavymetal content of soils and plant tissue. *Commun. Soil Sci. Plant. Anal.*, **18**, 1303-1316.
- Memon, M., Jamro G.M., Memon N., Memon K.S., Akhter, M.S. (2012). Micro nutrient availability assessment of tomato grown in teluka Badin, Sindh. *Pak. J. Bot.*, **44** (2), 649-654.
- Memon, M., Soomro, M.S., Akhtar, M. S., Memon K. S. (2010). Drinking water quality assessment in southern Sindh Pakistan. *Environ. Mont. Assess.* DOI 10.1007/s10661-010-1616-z.
- Moore, F., Sheykhi, V. Salari, M., Bagheri, A. (2016), Soil quality assessment using GIS-based chemometric approach and pollution indices: Nakhlak mining district, Central Iran *Environmental Monitoring Assessment*, **188**, 214

- Reza, S. K., Baruah, U., Singh, S. K., Das, T. H. (2015). Geostatistical and multivariate analysis of soil heavy metal contamination near coal mining area, Northeastern, *India Environmental Earth Sciences*, **73**, 5425–5433
- Saif, M.S., MirdadulHaq, Memon, K.S. (2005). Heavy metals contamination through industrial effluent to irrigation water and soil in Korangi area of Karachi, Pakistan. *International Journal of Agriculture and Biology*, **7** (4) 124-128.
- Sharma, K., Cheng, Z., Grewal, P.S. (2015). Relationship between soil heavy metal contamination and soil food web health in vacant lots slated for urban agriculture in two post-industrial cities, *Urban Ecosystem*, **18**, 835–855
- Yan, J., Quan, G., Ding, C. (2013). Effects of the combined pollution of lead and cadmium on soil urease activity and nitrification. *Procedia Environment Science*, **18**, 78 – 83.
- Yan, S., Shengji, Z. (2014). Study on soil heavy metals contamination of a lead refinery. *China Journal Geochemical*, **33**, 393–397
- Zhang, H., Cui, B., Xiao, R., Zhaoh, H. (2010). Heavy metals in water, soils and plants in riparian wetlands in the Pearl river estuary, South China. *Procedia Environmental Science*, **2**, 1344–1354
- Zhang, H., Liu, G., Li, W.S.J. (2014). Soil heavy metal contamination and risk assessment around the Fenhe reservoir, China, *The Bulletin of Environmental Contamination and Toxicology*, **93**, 182–186.
- Zhou, J., Feng, K., Pei, Z., Meng, F., (2016). Multivariate analysis combined with GIS to source identification of heavy metals in soils around an abandoned industrial area, *Eastern China Ecotoxicology*, **25**, 380–388
- Zubair, A., Begum, A., Khan, M.U. (2014). A study of coastal sediments of Sindh, Pakistan using geochemical approach for evaluation of heavy metals pollution. *World Applied Science Journal*, **30**(5), 581-587. DOI:10.5829/idosi.wasj.2014.30.05.37