Science of the Total Environment xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

# Assessment of groundwater pollution from ash ponds using stable and unstable isotopes around the Koradi and Khaperkheda thermal power plants (Maharashtra, India)

M. Voltaggio [a], M. Spadoni [a,*], E. Sacchi [b], R. Sanam [c], P.R. Pujari [c], P.K. Labhasetwar [c]

[a] CNR — Istituto di Geologia Ambientale e Geoingegneria, Via Salaria km. 29.300, 00010 Montelibretti, Roma, Italy
[b] Dept. of Earth and Environmental Sciences, University of Pavia and CNR-IGG, Via Ferrata 1, 27100 Pavia, Italy
[c] CSIR-National Environmental Engineering Research Institute, Nehru Marg, Nagpur 440020, India

## HIGHLIGHTS

- Ash ponds have wide environmental and social impact in India.
- Isotope ratios can be used as tracers for possible pollution of groundwater.
- Isotopes of O, H, Sr, U and Ra have been used to investigate the area of Koradi.
- Salinity of groundwater is not due to fly ash but linked to local brick kilns.
- A model for the residence time of water based on Ra isotopes is described.

## ARTICLE INFO

*Article history:*
Received 17 November 2014
Received in revised form 23 February 2015
Accepted 23 February 2015
Available online xxxx

Editor: Mae Mae Sexauer Gustin

*Keywords:*
Fly ash
Strontium isotopes
Uranium isotopes
Radium isotopes
Sulfate

## ABSTRACT

The impact on local water resources due to fly ash produced in the Koradi and Khaperkheda thermal power plants (district of Nagpur, Maharashtra — India) and disposed in large ponds at the surface was assessed through the study of environmental variation of ratios of stable and unstable isotopes. Analyses of oxygen and hydrogen isotopes suggest scarce interaction between the water temporarily stored in the ponds and the groundwater in the study area. Data also highlight that the high salinity of groundwater measured in the polluted wells is not due to evaporation, but to subsequent infiltration of stream waters draining from the ponds to the local aquifer. $^{87}Sr/^{86}Sr$ values, when associated with Sr/Ca ratios, demonstrate the dominant role of waste waters coming from tens of brick kilns surrounding the pond sulfate pollution. Uranium isotopic analyses clearly show evidence of the interaction between groundwater and aquifer rocks, and confirm again the low influence of ash ponds. A new conceptual model based on the study of the isotopes of radium is also proposed and used to estimate residence times of groundwater in the area. This model highlights that high salinity cannot be in any case attributed to a prolonged water–rock interaction, but is due to the influence of untreated waste water of domestic or brick kiln origin on the shallow and vulnerable aquifers.

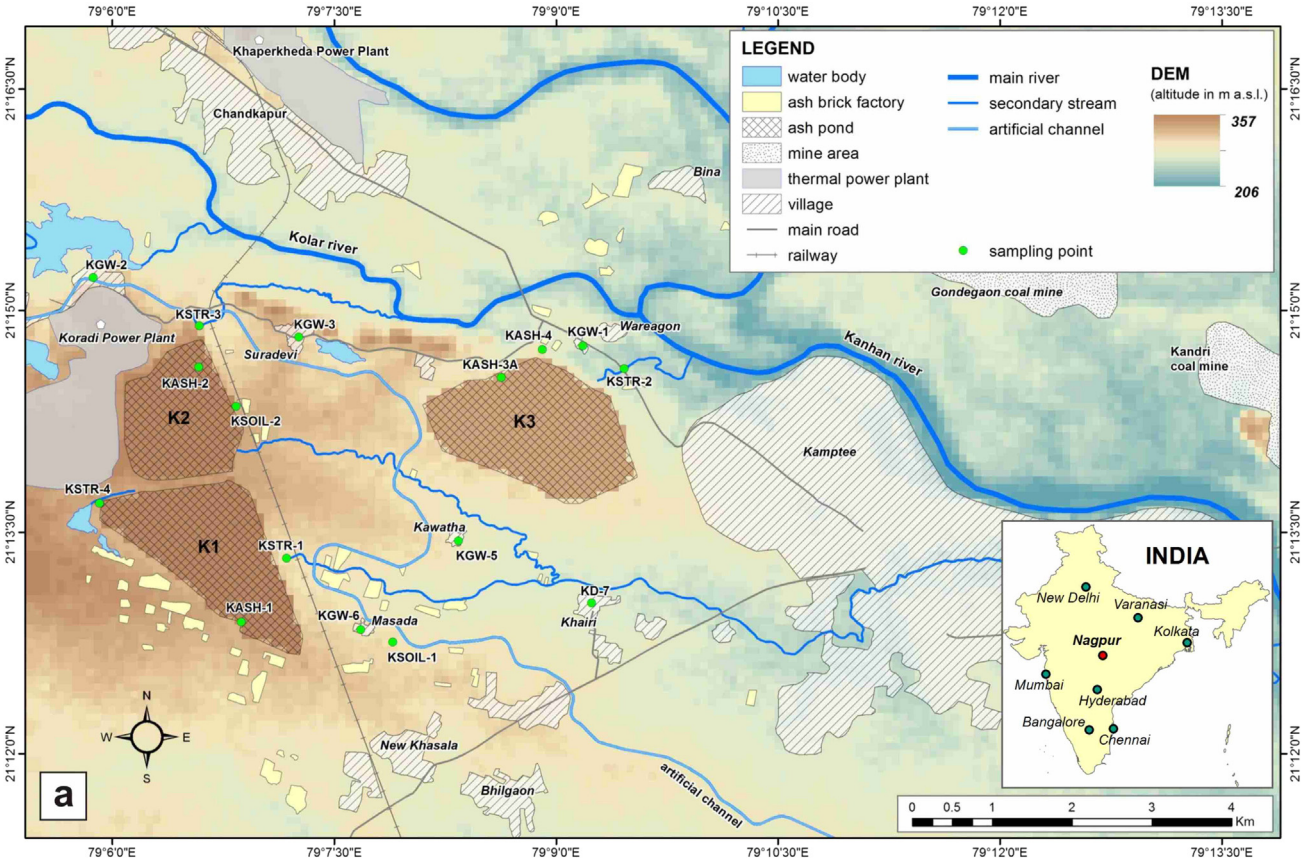


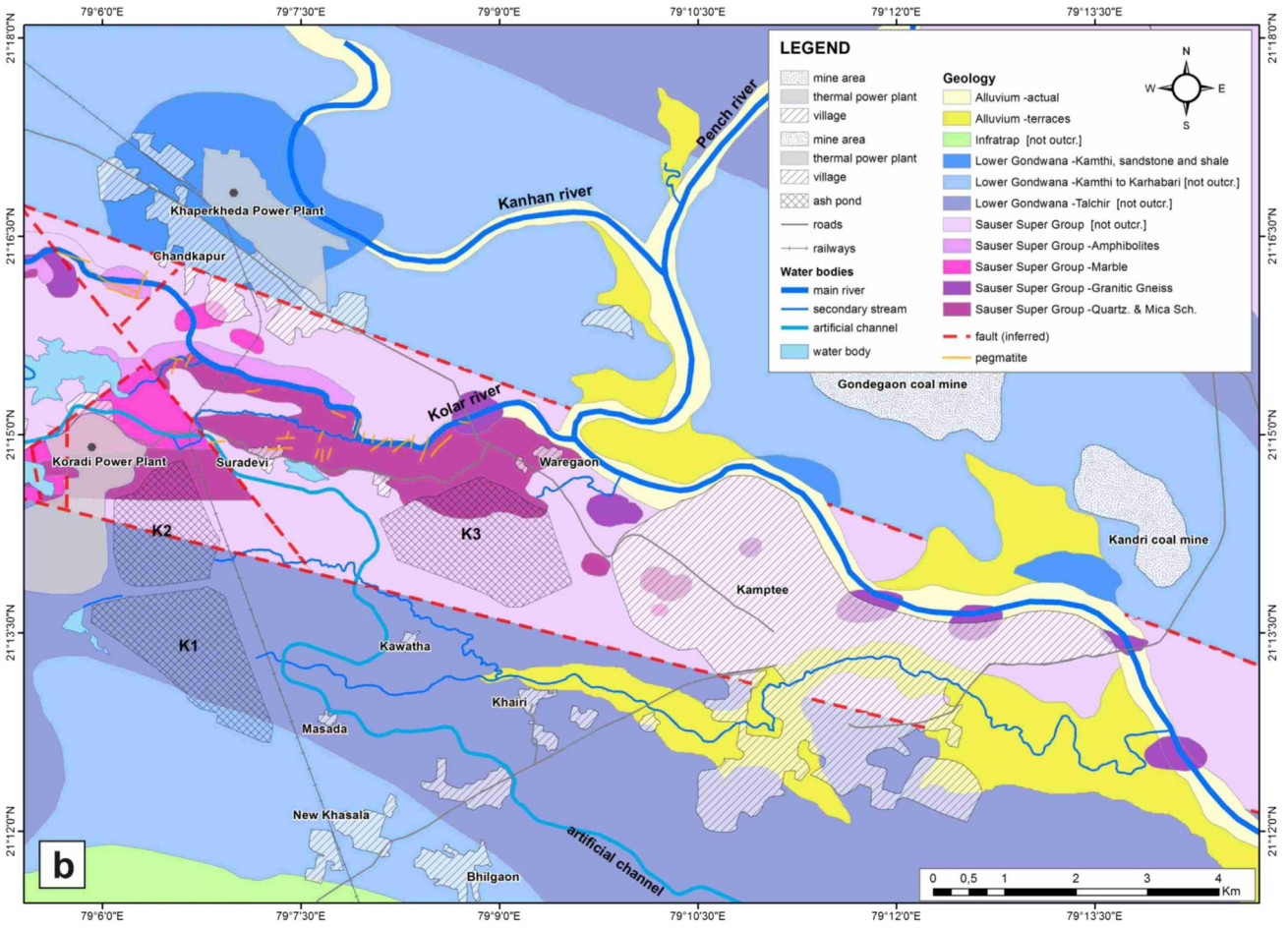
## 1. Introduction

Fly ash is a by-product of thermal power plants generated by the burning of powdered coal in the boiler furnace, and can be described as fine particles that mobilize along with hot flue gasses which pass through electrostatic precipitators before being evacuated pneumatically. In India, out of 290 million tonnes of industrial waste, nearly 130 million tonnes of fly ash and roughly 30 million tonnes of bottom ash are being generated by thermal power plants as a by-product of the coal combustion (Singh et al., 2008). Before their disposal, fly-ash particles are mixed with bottom-ash, which are particles with a larger size that collect at the bottom of the furnace. Disposal, in the form of a sludge, is usually carried out in large artificial ponds (ash ponds) located nearby the power plants. The abundance ratio between fly ash and bottom ash in the mixture disposed in the ponds is variable but generally close to 5:1 in weight (e.g., Kim et al., 2005). The same abundance ratio also characterizes the ash produced by the Koradi and Khaperkheda thermal power plants, located in the district of Nagpur (Maharashtra — India), and under operation since 1974 and 1989 respectively, with an effective total power generation capacity of 620 MW and 880 MW respectively. Here, only considering the years 2006/2007, 1.6 MT of ash were generated, representing about 30–35% of the coal used in the plants (World Bank, 2008).

* Corresponding author.

http://dx.doi.org/10.1016/j.scitotenv.2015.02.083
0048-9697/




Please cite this article as: Voltaggio, M., et al., Assessment of groundwater pollution from ash ponds using stable and unstable isotopes around the Koradi and Khaperkheda thermal power plants (Maharashtra, India), Sci Total Environ (2015), http://dx.doi.org/10.1016/j.scitotenv.2015.02.083