Assessment of Chromium Pollution at Nuasahi-Baula Mines, Orissa

presented
by

Dr. Sk. Md. Equeenuddin

Dept. Mining Engineering
National Institute of Technology
Rourkela, Odisha

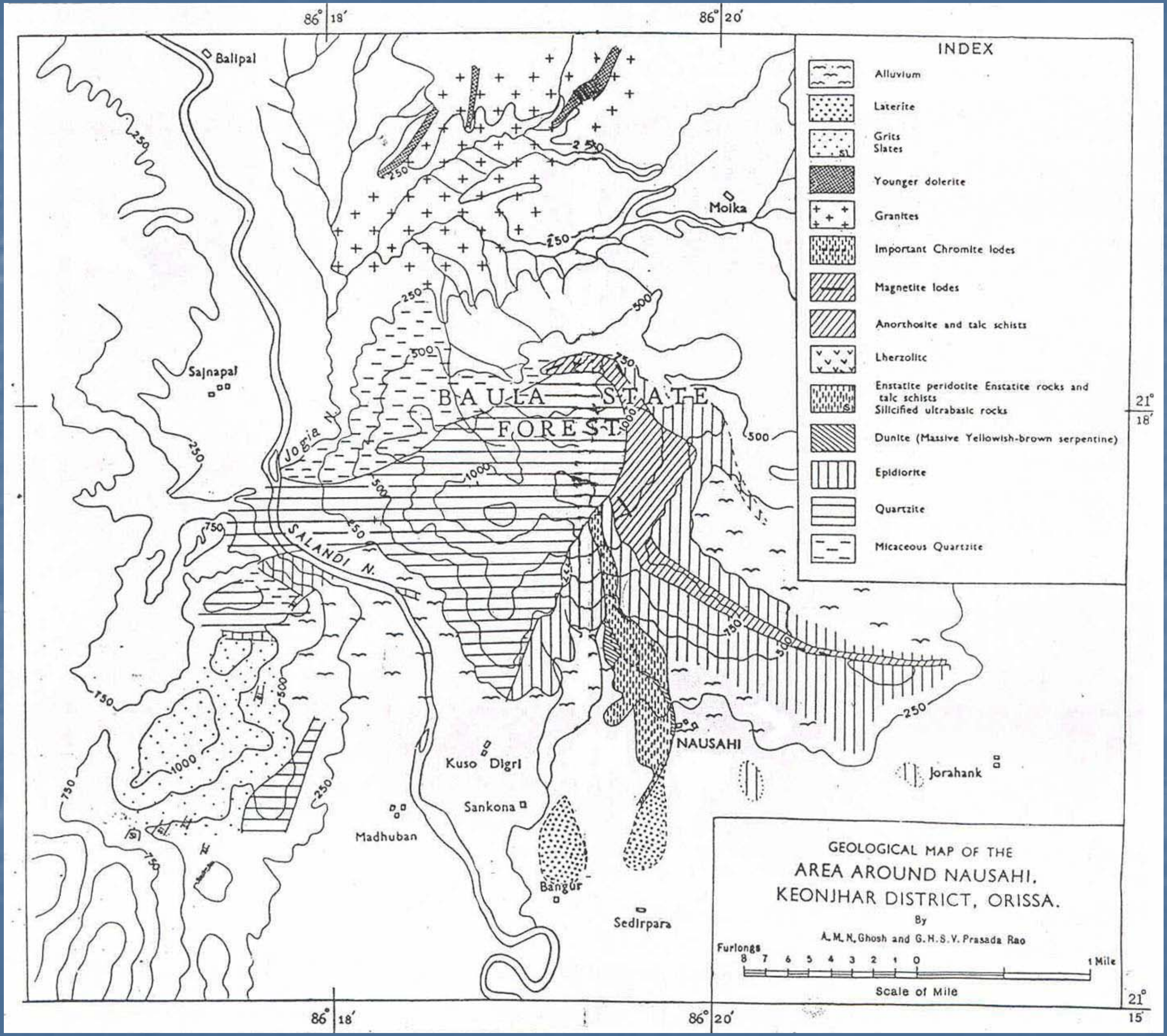
Introduction

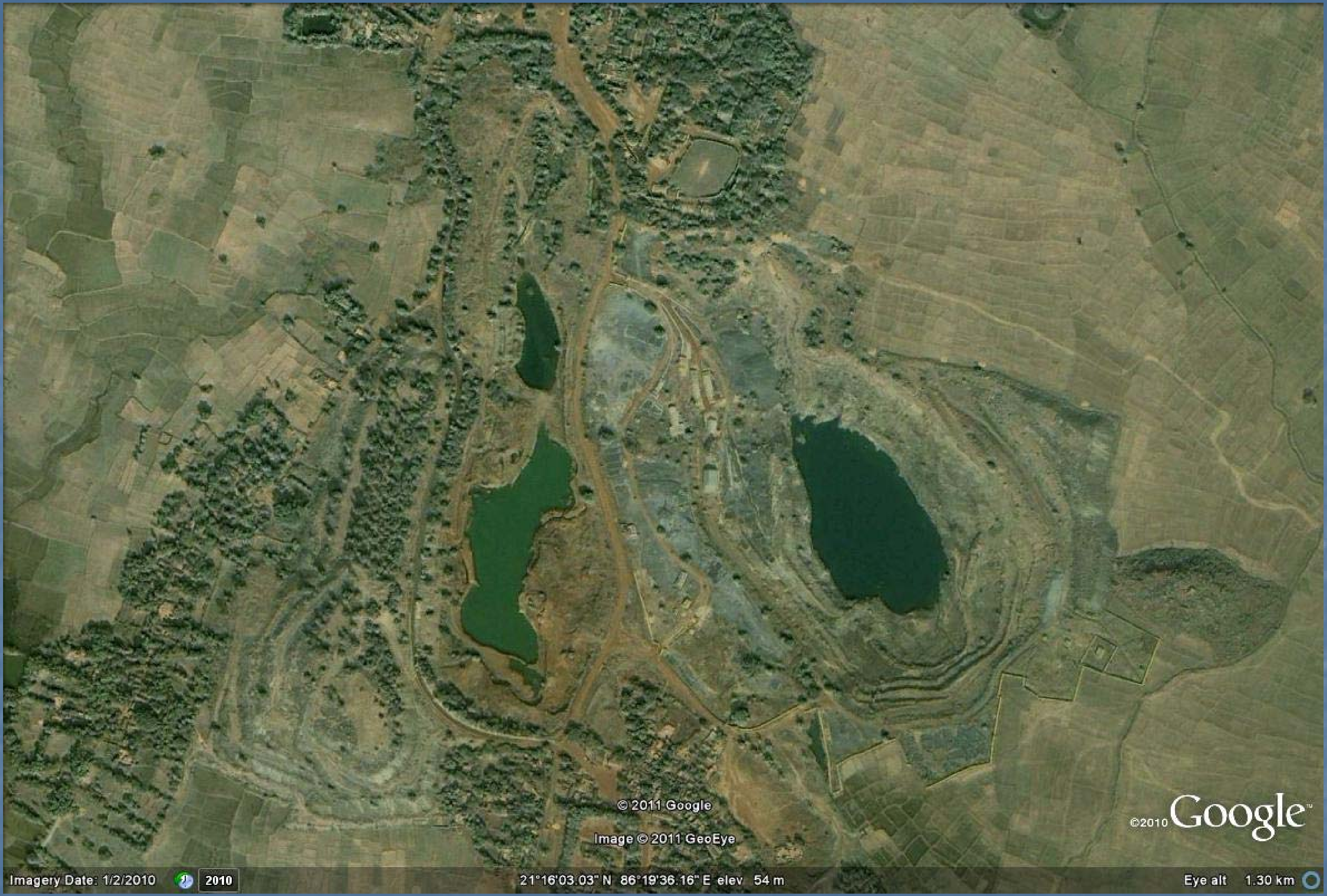
- Environmental pollution due to Cr and its compound is caused from large number of industrial uses such as leather processing, hide tanning, refractory steel, metal plating, electroplating industries, catalytic manufacturer, production of chromic acid and wood preserving
- Cr contamination is also resulted from natural processes like weathering of ultramafic rocks and leaching of overburden
- Assessment of Cr occurrence is very important particularly in the area containing mafic to ultramafic rocks

Study Area

- Some of the richest chromite deposits of the country are located within the Nuasahi-Baula igneous complex in Keonjhar District which is about 70 km northeast of the more famous Sukinda ultramafic belt in Jajpur district
- Chromite ore occur as bands, lenses and pockets in weathered (serpentinized) dunite-peridotite group of rock
- Stratiform nature of the chromite bearing ultramafics extends for nearly 3 km with maximum width of around 1 km

Geological Map at Baula- Nuasahi




© 2011 Google
Image © 2011 GeoEye
©2010 Google
Imagery Date: 1/2/2010
2010
21°16'03.03" N 86°19'36.16" E elev 54 m
Eye alt 1.30 km

Materials and Methods

- Mine discharges were collected from OMC and IMFA quarries and also from surface run-up
- Groundwater from the villages
- Soil, lateritic cover and overburden were also collected from the surroundings
- Cr (VI): colorimetric method using diphenylcarbazide solution
- Total Cr: Atomic Absorption Spectrophotometer
- pH: Ion Selective Electrode
- Desorption of Cr(VI) using saline and phosphate solution, and tap water
- Total Cr in solid sample using XRF
- Fractionation of Cr using Tessier Method

Chromium in Water

Sample	pH	Cr(VI) (ppb)	Total Cr (ppb)
Mine Discharge water	7.7	11	13
	7.6	14	15
	7.9	36	42
	7.8	8	9
Ground water	7.5	BDL	BDL
	6.7	BDL	BDL
	6.7	2	2
	7.2	6	7

Vertical Weathering Profile

Zone	Mineral Proportions
Laterite (Ferricrete) Zone 2 to 8m below Ground Level (GL)	Go>Ka>Ser>Qtz>Mgh ± Chr ± Sm
Mottled Zone 8 to 13m below GL	Go>Talc>Ser>Sm>Mgh ± Lep
Pallid Zone 6 to 12m below GL	Ser > Qtz > Talc> Sm (?)
Fresh Rock more than 8 - 12m from GL	Talc>Qtz>Augite>Ol Hb>Augite>Chr And>Talc

Cr(VI) Retention by Laterite

- Chromium is mined as its oxide ore chromite $FeO.Cr_2O_3$.
- The FeO component of primary minerals like chromite, olivine and serpentine has been oxidized to group of Fe(III) like goethite , $Fe_2O_3.H_2O$ and maghemite, γ- Fe_2O_3.
- These are the main constituents of the thick laterite-limonite overburden over the ore body
- It is apparent that under the same oxidizing condition Cr(III) in chromite is mobilised into groundwater as the hexavalent CrO_4^{2-} ion. The overall process can be represented by a reaction of the type:

$$\text{Chromite} + 7/2\ O_2 + 5H_2O = \text{goethite} + 4\ CrO_4^{2-} + 8H^+$$

One major constituent of laterite soils is Hydrated Ferric Oxide (HFO). In colloidal size fraction, the Fe – OH functional groups at the interface between mineral and water show pH-dependent surface charge.

At low pH , a protonation reaction like

$$\equiv Fe - OH + H^+ \longrightarrow [Fe - OH_2]^+$$

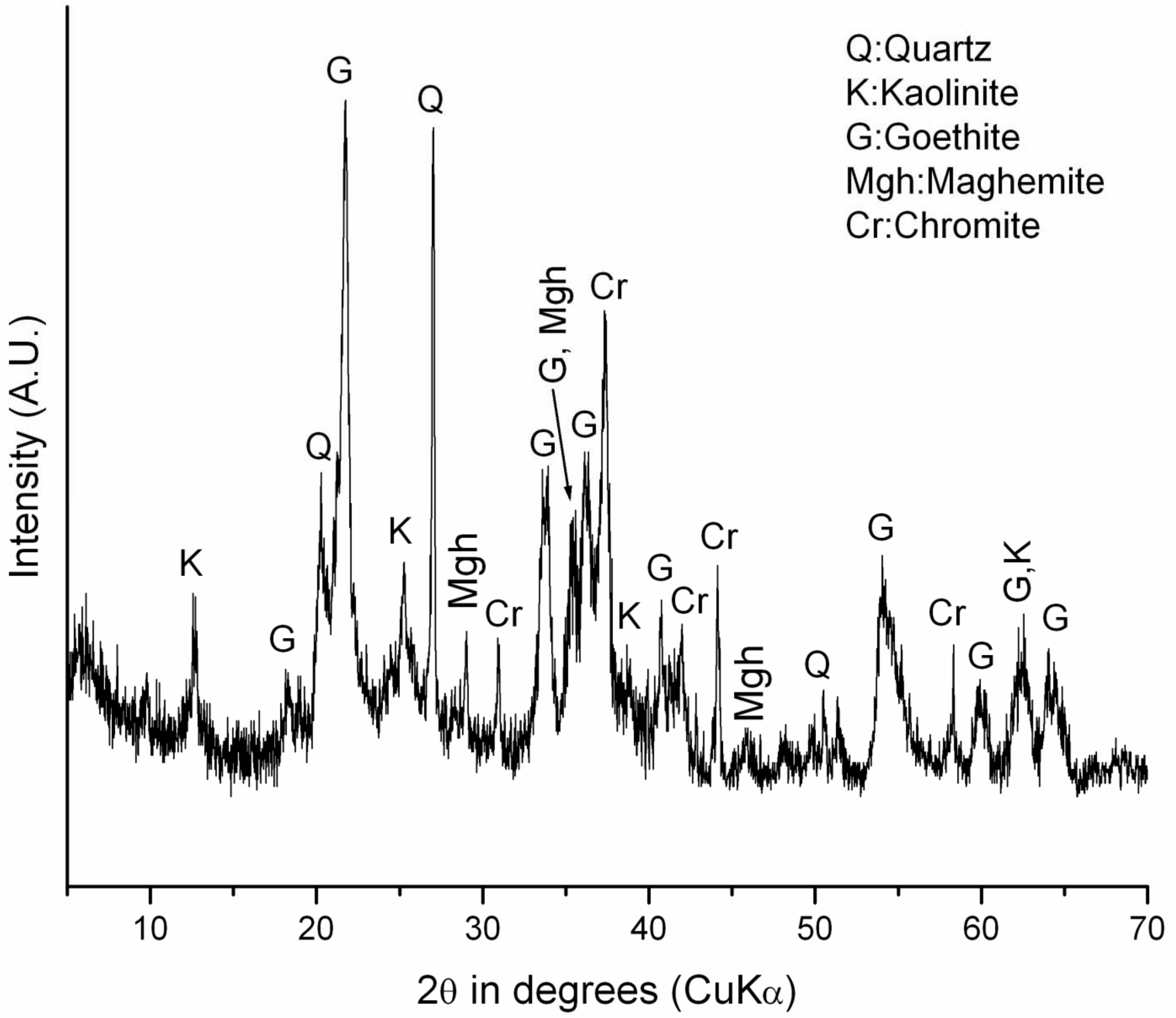
At high pH values, dissociation or de-protonation takes place by reaction such as:

$$\equiv Fe-OH + (OH)^{-} \longrightarrow [Fe\text{-}O]^{-} + H_2O$$

$$\equiv Fe-OH \longrightarrow [Fe\text{-}O]^{-} + H^{+}$$

or,

Mineralogy of Lateritic Cover

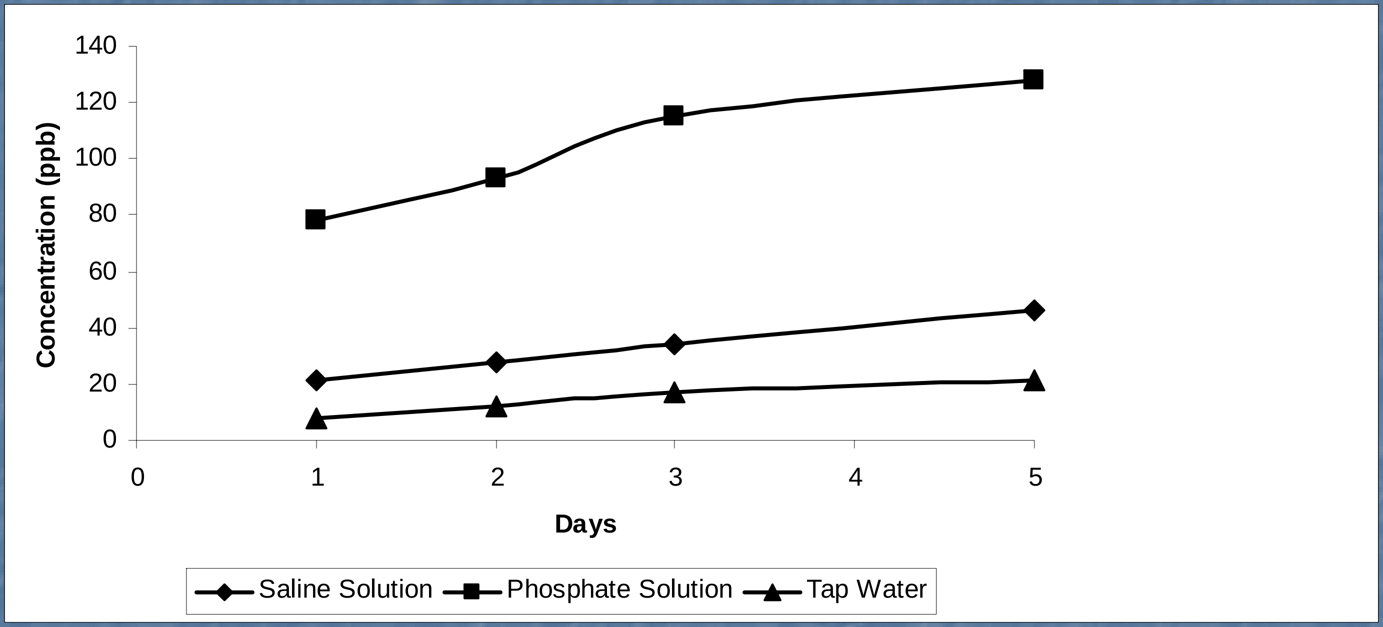


Desorption Experiment

In order to estimate the quantity of Cr(VI) can be released under various condition (1:100)

- Phosphate solution (0.1 M KH_2PO_4)
- Tap water
- Saline solution ($NaCl$-$NaHCO_3$) at pH 8

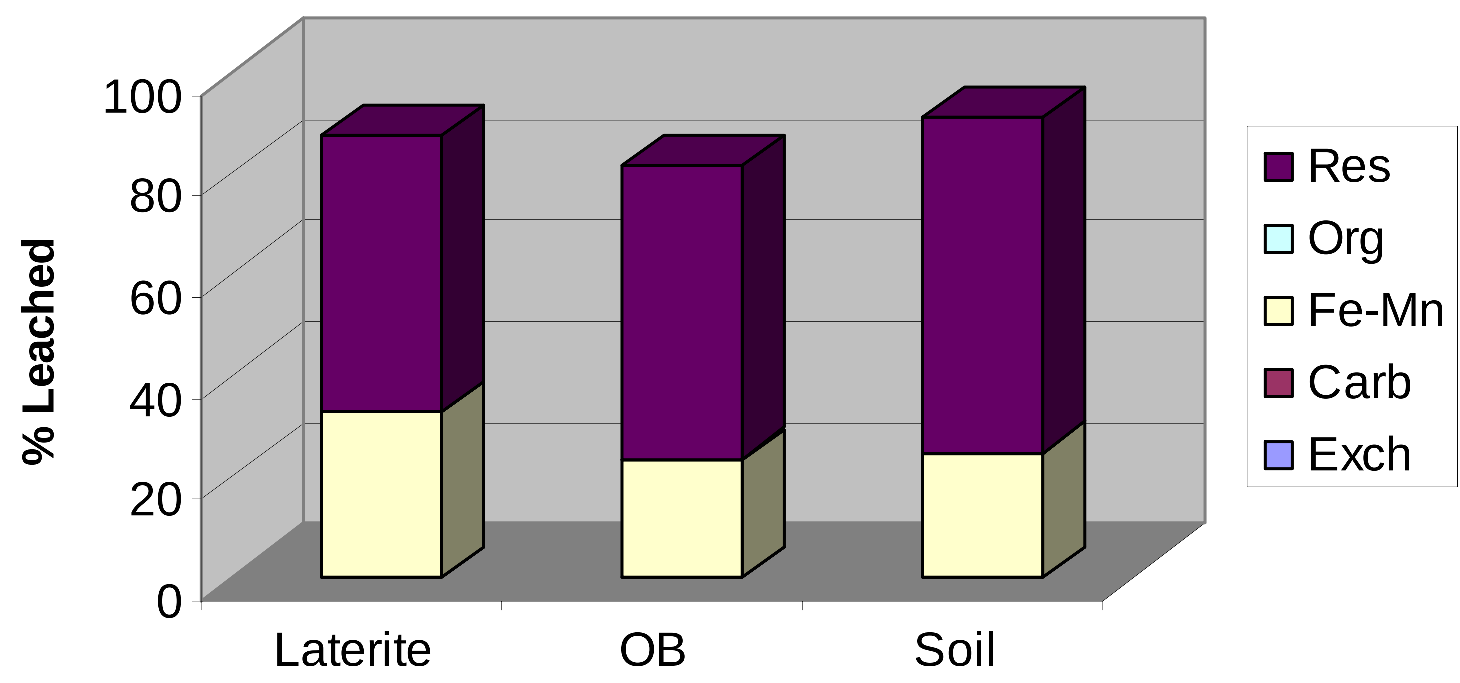
Desorption Experiment



Sequential Extraction of Cr

Sample + 8ml 1M MgCl2 at pH 7(1h)	Exchangeable
8ml of 1M Na- acetate adjusted to pH 5 (5h)	Carbonate
20ml 0.04M NH2OH.HCl in 25% acetic acid at pH 2 (shaken in water bath for 6h)	Fe-Mn oxide
3ml 0.02M HNO3, 8ml 30% H2O2 heated for 5h at 85 degree C	Organic
Concentrated mixture of HNO3 +HCl+HF	Residual

Sequential Extraction of Cr



Conclusions

- Concentration of Cr (VI) is more in mine water in comparison to groundwater
- Cr(VI) is retained by the goethite rich lateritic cover
- Phosphate solution releases maximum Cr(VI)
- Total Cr in the soil and overburden is very high
- Bioavailability of Cr is less, and mostly associated with residual fraction and reducible fraction (Fe-Mn oxyhydroxides)

Thank You