Bioremediation of Chromium Containing Solid Waste and Ground Water in Ranipet Industrial Estate, Tamil Nadu

Dr. K. Ranganathan
and
S. Suresh

Central Pollution Control Board,
Zonal Office (South),
Shivanagar,
Bangalore- 560 010

Introduction

- Bio-remediation is the use of microorganism metabolism to remove pollutants.
- Technology can be generally classified as *in situ* or ex situ. *In situ* involves treating the contaminated material at the site and *ex situ* involves the removal of contaminated material to be treated elsewhere.
- Examples of bioremediation technologies are phytoremediation, bioventing, bioleaching, land farming, bioreactor, bio- augmentation and bio-stimulation etc.,

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Hazardous Waste which because of its quantity, concentration, or physical, chemical nature, possesses the characteristics of *corrosive or explosive ,flammable, toxic* and *reactive,* causes danger or likely to cause danger to the health and environment whether alone or when in contact with other wastes. The waste can physically be a solid, liquid, semi-solid, or container of gaseous material.

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- The wastes containing hazardous chemicals such as are arsenic, mercury, hexavalent chromium, Cadmium, selenium, PAH, PCBs and OC-Pesticides are more toxic and persistent.

- When those toxic wastes unscientifically disposed, they are leached out from the wastes and contaminate ground water, surface water and soil, which are very dangerous to the human health and the environment.

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- According to the report of CPCB, in India, there are 41, 523 numbers of hazardous wastes generating industries and they generate 79 lakhs tons of wastes per annum.
- The hazardous wastes are classified as Recyclable (50%), incinerable (5%) and land fillable (45%) wastes with or with out stabilization.
- The wastes shall be disposed to Registered recyclers, incinerators and SLF, respectively.

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- When there was Acts and Rules for control of water pollution and air pollution, but no Act and Rule for control of such hazardous wastes till end of 1990.
- Hazardous wastes (M & H) Rule, 1989 was made under the provision Environment (Protection) Act, 1986 and necessary guidelines were issued.
- Till that period the wastes were disposed unscientifically.

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- As dedicated legislation was promulgated in India to manage the hazardous wastes only after 1989, Illegal dumping and disposal has been happened after industrial development that resulted in number of contaminated sites all over the country.
- MoEF/CPCB identified 73 numbers of such sites all over the country that needs to be remediated.

History of contaminated site

- One of such contaminated site available in Tamil Nadu is TCCL, Ranipet. It was in operation for production of sodium bi-chromate and basic chromium sulphate for around 20 years.
- Around 1.6 to 2.0 lakh tons of wastes containing 200 mg/kg of Cr (VI) and 10, 000 mg/kg total chromium is spread on 2.5 hectares of land.

History of the contaminated site

- Operation of the industry was stopped in 1994 and it was working for 20 years during the period accumulation.

- Leachate from the site are running during monsoon season and contaminated ground water and surface water. The ground water contains 180 mg/l of Cr(VI). The surface run off flows with 20 mg/l of chromium (VI).

Method of Bioremediation -Biomass

Native Soil in the site area contaminated with Cr was rinsed with sterile water to get microbial seed.

It was cultured with sugar solution to obtain biomass of 50,000 mg/l. The predominantly identified organism was pseudomonas.

The biomass enriched with sugar/molasses was used for remediation of both the sludge containing chromium and aquifer contaminated with chromium .

Bioremediation of sludge

- A cement concrete platform (10 mx 3 m) was made near the dump site with in the TCCL factory premises.

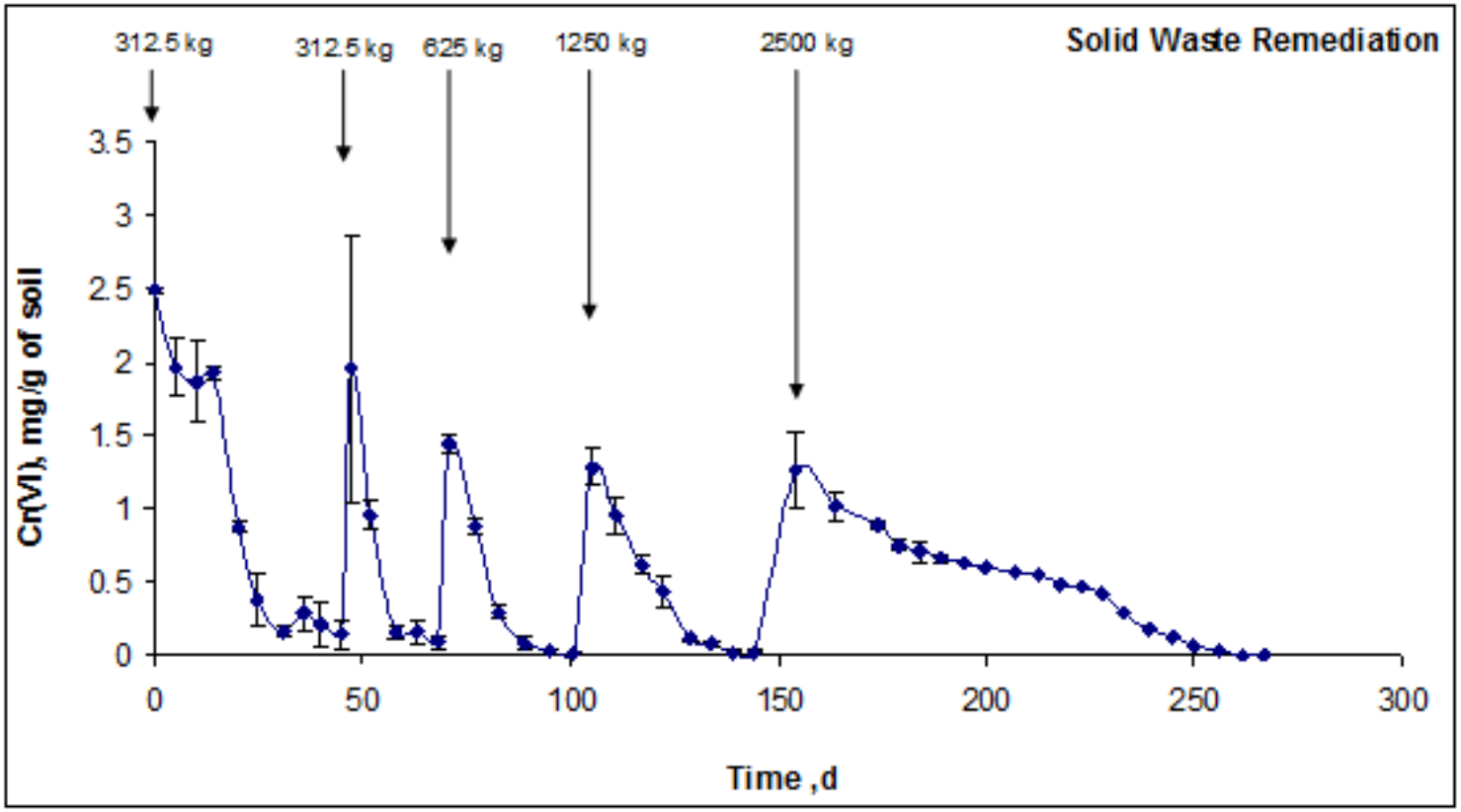
- 175 kg of the sludge was taken, loosened and homogenized. Mixed with enriched bacterial biomass (40 L), along with molasses of 1 kg (Jiggery). On 5^{th} day again addition of 137.5 kg along with biomass and nutrient was continued. The samples were periodically taken and analyzed for chromium. Addition biomass stopped on 13^{th} day and molasses was continued until the 225 day. Moisture content of 40% was maintained.

- Sludge quantity was doubled on 46^{th} , 70^{th} , 105^{th} and 154^{th} day and molasses was added. This process was continued until all the 5 tones of soil were remediated.
- The bioremediation was continued for 270 days and continuous monitoring was also carried out.
- Both hexavalent chromium and total chromium were tested using the standard methods after preservation.

Results of the study

- Five tons of sludge has been remediated with in 256 days of the experiment.
- Addition of biomass was stopped with in 13 th days however, nutrients and water were added periodically.
- Cr (VI) concentration has been reduced from 2500 mg/kg to BDL level after 267 days however total chromium remains same.

Graph of Chromium remediation



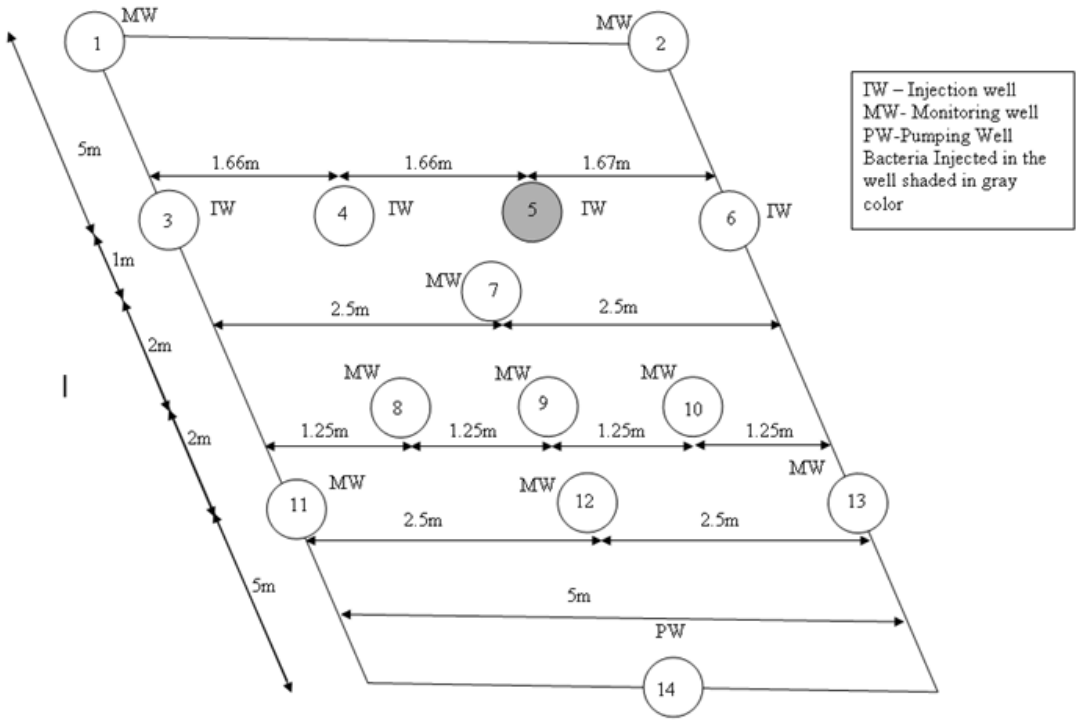
Photographic views of the sludge before and after treatment

Photographic views of the leachate before and after treatment

Bioremediation of Aquifer

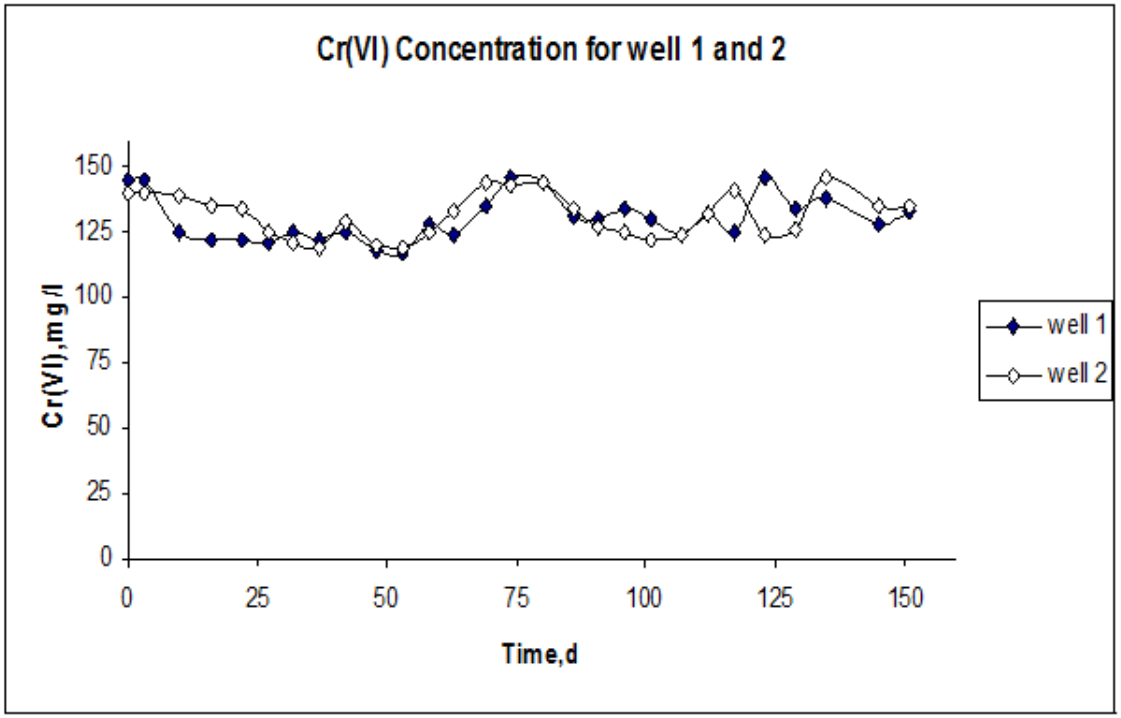
- Four injection wells and an array of monitoring wells (Total 13) were installed in the designated 5 m × 5 m area in the TCCL compound (Fig 1).
- One pumping well was also installed at a distance of 10 m from the line of injection wells.
- Enriched microbes (1 kg) and sugar (5 kg) were injected into the aquifer through the injection well Nos. 3-6. Every alternative 3 days , nutrient was added and samples were collected.
- The microbes which were injected have been enriched and isolated from the very same site at Ranipet. The fate and transport of chromium (both Cr(VI) and Cr(III)), molasses were monitored at regular intervals.

Monitoring wells locations

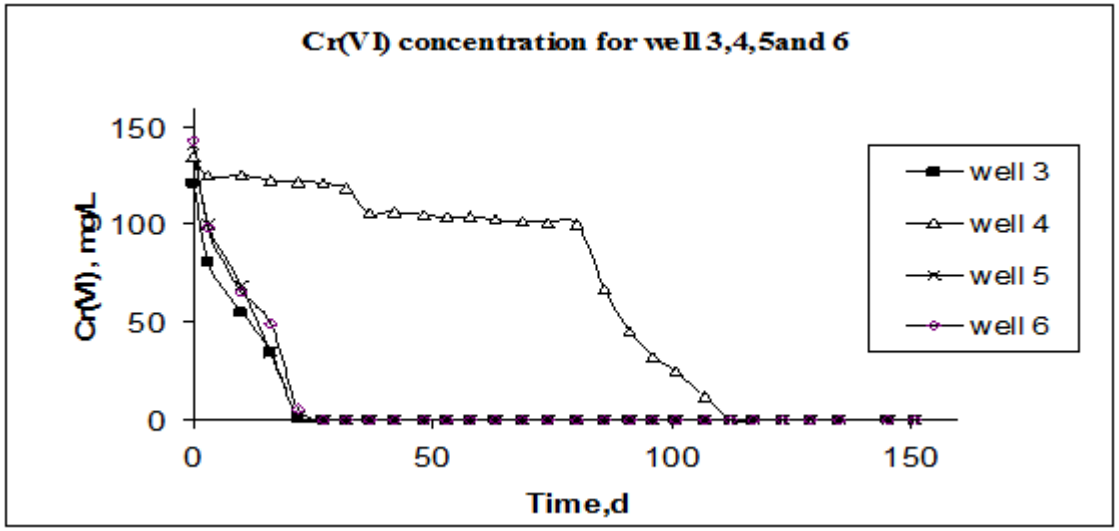


Photographic view of ground water

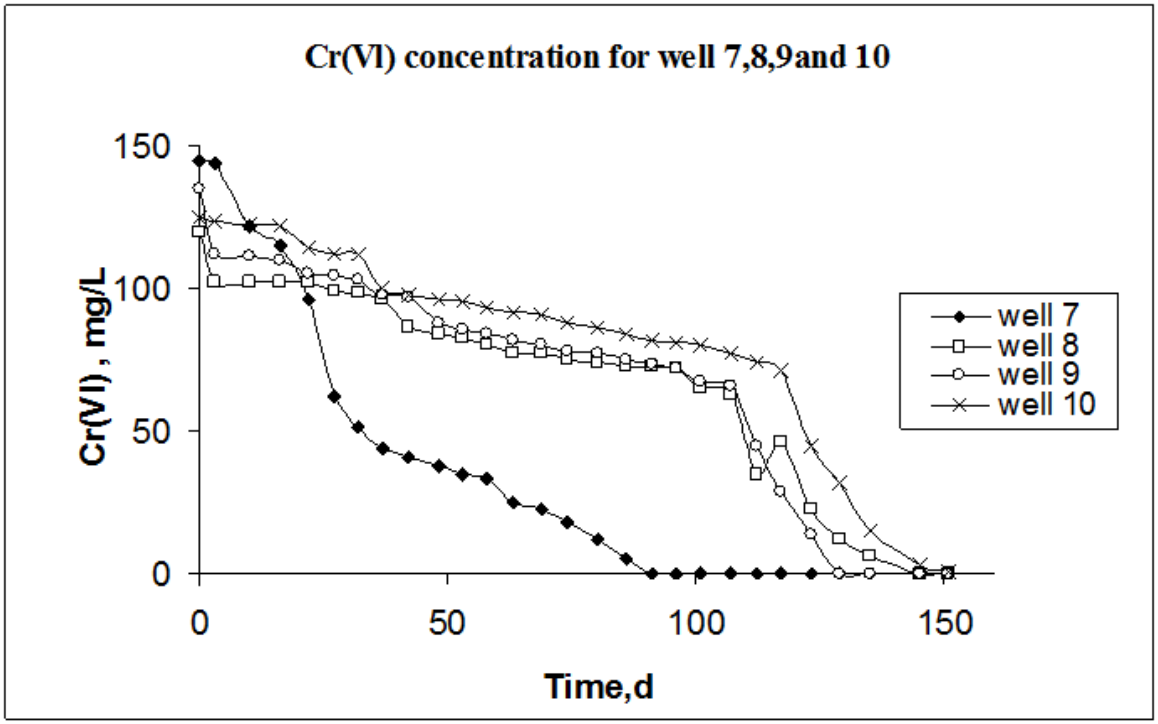
concentration with respect to time in wells 1 and 2



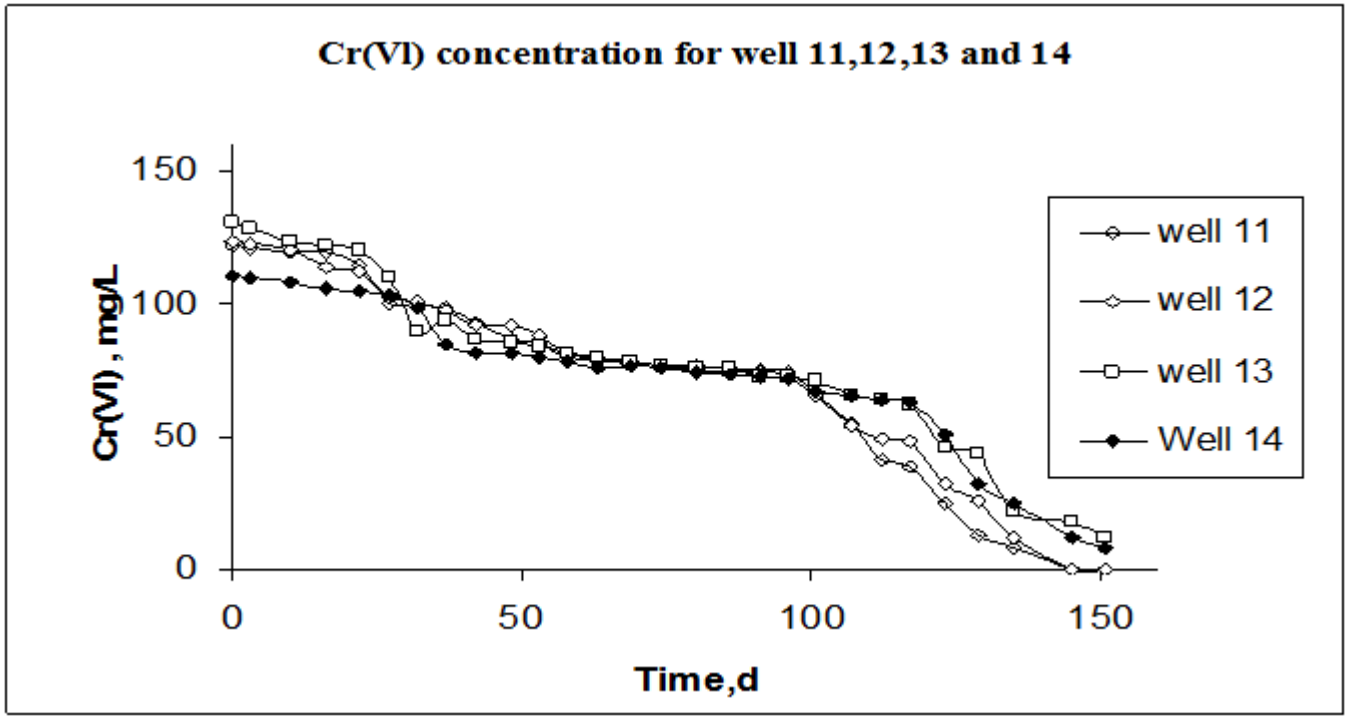
Variation of Cr (VI) concentration with respect to time in wells 3, 4, 5 and 6



Variation of Cr (VI) concentration with respect to time in wells 7, 8, 9 and 10



Variation of Cr (VI) concentration with respect to time in wells 11 to 14



Ground water before bio remediation

Bio remediated ground water

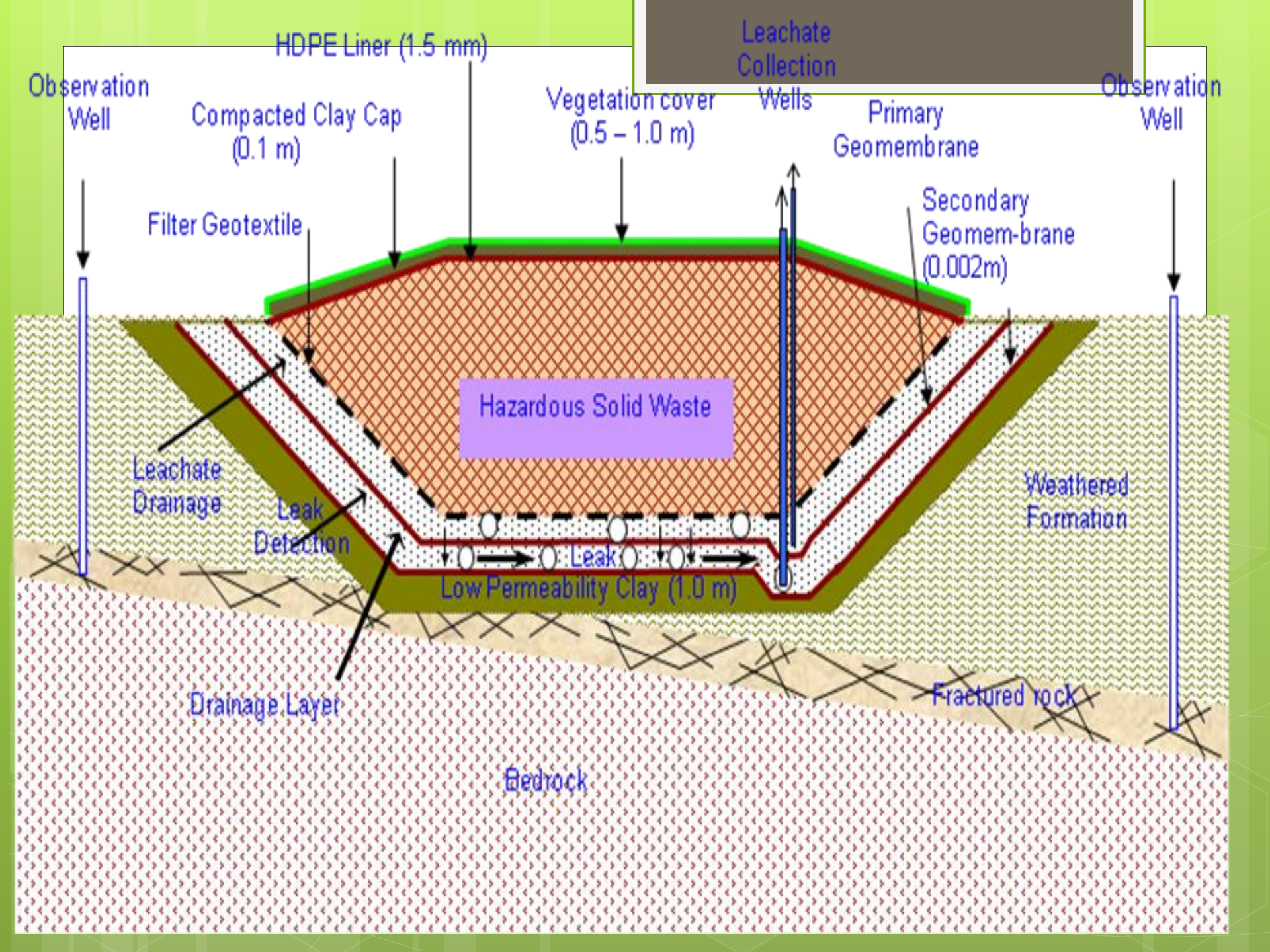
Parameter	Control Point	Injection well	Monitoring well-8	Monitoring well-9	Monitoring well-11
pH	10.10	4.60	6.00	7.00	7.9
TDS, mg/l	1477	-	1522	2048	1720
COD, mg/l	BDL	15	18	17	17
Chloride, mg/l	97	504	138	129	116
Sulphate, mg/l	286	37	221	28	92
Sodium, mg/l	574	2364	730	724	652
Cr (VI), mg/l	148	0.61	0.24	0.07	0.3

Summary of soil bioremediation

- Bioremediation of chromium contaminated soil was successful, without continuous addition of biomass. Biomass needs to be added only once to the initial batch of contaminated soil. Carbon source (molasses, sugar etc.) and moisture (water) needs to be added as and when needed (once in 10 days). Moisture content of about 40% is to be maintained.
- Remediation of a large quantity of contaminated soil is constrained only by the availability of initial biomass, and the space for mixing and heaping.
- The time needed for remediation of entire contaminated soil if enough biomass is available to start the remediation process for a large quantity of soil.
- TCLP and water leaching from the remediated soil did not show Cr(VI), whereas water leaching from un-remediated soil showed high concentration of Cr(VI).

Summary of aquifer remediation

- Bioremediation of aquifer using reaction zone technology was successful.
- Bacteria need to be injected into the aquifer through injection wells only initially. However, carbon source (molasses, sugar etc.) need to be added at regular intervals (once in 7 to 10 days).
- Excessive addition of carbon source and bacteria remediates the aquifer very quickly, but there could be a chance of aquifer clogging in case of continuous feeding for aquifers where the source of contamination is not arrested.
- Sugar as a carbon source worked very well, without leaving any residual color.
- Cr(III) in the remediated aquifer was completely adsorbed on to soil matrix and the water was free from Cr(III).


Leachate Collection Wells
HDPE Liner (1.5 mm)
Observation Well
Compacted Clay Cap (0.1 m)
Vegetation cover (0.5 – 1.0 m)
Primary Geomembrane
Observation Well
Filter Geotextile
Secondary Geomem-brane (0.002m)
Hazardous Solid Waste
Leachate Drainage
Leak Detection
Weathered Formation
Leak
Low Permeability Clay (1.0 m)
Drainage Layer
Fractured rock
Bedrock


Thank You