

Goa State Pollution Control Board

Summary Report

Republic of India

Pilot Survey for Disseminating SME's  
Technologies for Groundwater Remediation  
by Bioremediation of the Sal River and  
Bethora Industrial Estate in Goa

March 2016

Japan International Cooperation Agency

(Asahi Geo Survey Co. Ltd.)

## 1. BACKGROUND

While India is experiencing significant economic growth, pollution from industrialization and water resource depletion are seriously damaging the country's groundwater. Thus, India has listed river purification of the Ganges and pollution cleanup in orphaned legacy polluted sites as part of its national environmental cleanup policy in one of their national missions within the current Twelfth Five-Year Plan. Further, according to the report, "Governmental Commission on the Projects for ODA Overseas Economic Cooperation in FY 2012" prepared by Asahi Geo Survey Co., Ltd. (AGS), all related state and central government agencies were acknowledged to have serious concerns about the groundwater situation resulting in serious health hazards for the local population.

## 2. SURVEY OUTLINE

### (1) Purpose

This survey utilizes an integrated groundwater remediation unit to assess the effectiveness and advantages of using biostimulants to promote native microorganisms in the soil to remediate contaminated groundwater, and contributes in the future to restore the health of water environments in Goa State that had been polluted as a result of industrialization.

This survey also aimed to evaluate the feasibility of conducting environmental investigations and bioremediation cleanup operations in Goa State.

### (2) Scope of Work/Activities

First, two environmental investigations should be executed: (1) Site inspection (Phase I Environmental Site Assessment) and (2) soil and groundwater sampling investigation (Phase II Investigation). The objective of both investigations was to determine the extent of hexavalent chromium and other heavy metal contamination in the Sal River basin (Salcette region), including the Cuncolim Industrial Development Corporation (IDC), and in the Bethora IDC. Then, in the event that the above investigations identified hexavalent chromium and/or other heavy metal contamination at levels posing human health risks, pilot-scale bioremediation would be performed and a full-scale bioremediation plan would be developed.

If no significant hexavalent chromium contamination is identified in the Salcette region and the Bethora IDC during the above investigations, AGS will conduct a field demonstration for the Goa State Pollution Control Board using the integrated groundwater remediation unit

### (3) Information of Product/ Technology to be Provided

This survey consists of a pilot-scale groundwater remediation test for groundwater contaminated with hexavalent chromium, using an integrated groundwater remediation unit. The remediation

unit is comprised of a biostimulant injection unit and related apparatuses for bioremediation. The biostimulant “EDC-M™” is a nutritional supplement made from food materials and is a certified product in Japan. EDC-M™ is known for its safety performance and has been used to successfully remediate over 200 contaminated sites in Japan and abroad. EDC-M™ stimulates the native microorganisms present in the groundwater to promote the rapid and natural remediation of hexavalent chromium.

EDC-M™ treatment is coupled with a pre-treatment system using ion-exchange resins and photocatalysts to remove hexavalent chromium. This survey also includes groundwater simulation modeling using the GETFLOWS™ simulator.

#### (4) Counterpart Organization

Goa State Pollution Control Board (GSPCB)

#### (5) Target Area and Beneficiaries

This survey targeted the Sal River basin area and the Bethora Industrial Estate in Goa. The Sal River basin includes the Cuncolim Industrial Estate. The region is very concerned about the serious water pollution and is backed by the highly motivated Goa State Pollution Control Board (GSPSB) in terms of environmental cleanup.

The millions of residents who use the groundwater in the survey target areas are all primary direct beneficiaries. Consumers of agricultural products from the target areas are the secondary and indirect beneficiaries, while the Pollution Control Board and the Ministry of Environment and Forests will also benefit from the Survey as it contributes to the national mission.

#### (6) Duration

This survey started in February 2014 and concluded in March 2016.

#### (7) Progress Schedule

The progress schedule is shown below in Figure 1.

#### (8) Manning Schedule

The manning schedule is shown below in Figure 2.

#### (9) Implementation System

The implementation system is shown below in Figure 3.



Figure 2 Manning schedule

	title	name	company	2013			2014												2015												2016			man / days		
				2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	India	Japan					
Operation in India	General Manager / Development of Business Model	Fumio Hotta	AGS			■																													8	
	Chief Advisor / Development of Remediation Model	Kanji Tamamushi	RPEICO	■			■															■		■										48		
	Project Manager	Shunsuke Kawakami	AGS	■	■		■	■		■														■		■								148		
	Data Gathering	Aya Hirano	AGS																																15	
Operation in Japan	General Manager / Development of Business Model	Fumio Hotta	AGS		□	□	□																												22	
	Chief Advisor / Development of Remediation Model	Kanji Tamamushi	RPEICO	□		□	□															□													22	
	Project Manager	Shunsuke Kawakami	AGS	□		□																□						□							33	
	Technical Support	Aya Hirano	AGS	□	□	□	□																						□						33	
	Data Gathering	Misako Mori	RPEICO	□	□																								□						14	
																											man / month (prime contractor)		3/ 5.70	3/ 2.93						
AGS: Asahi Geo Survey Co. Ltd.																											man / month (external personnel)		1/ 1.60	2/ 1.20						
RPEICO: Relo Panasonic Excel International Co., Ltd.																											Total man / month		4/ 7.30	5/ 4.13						

 in India  
 in Japan

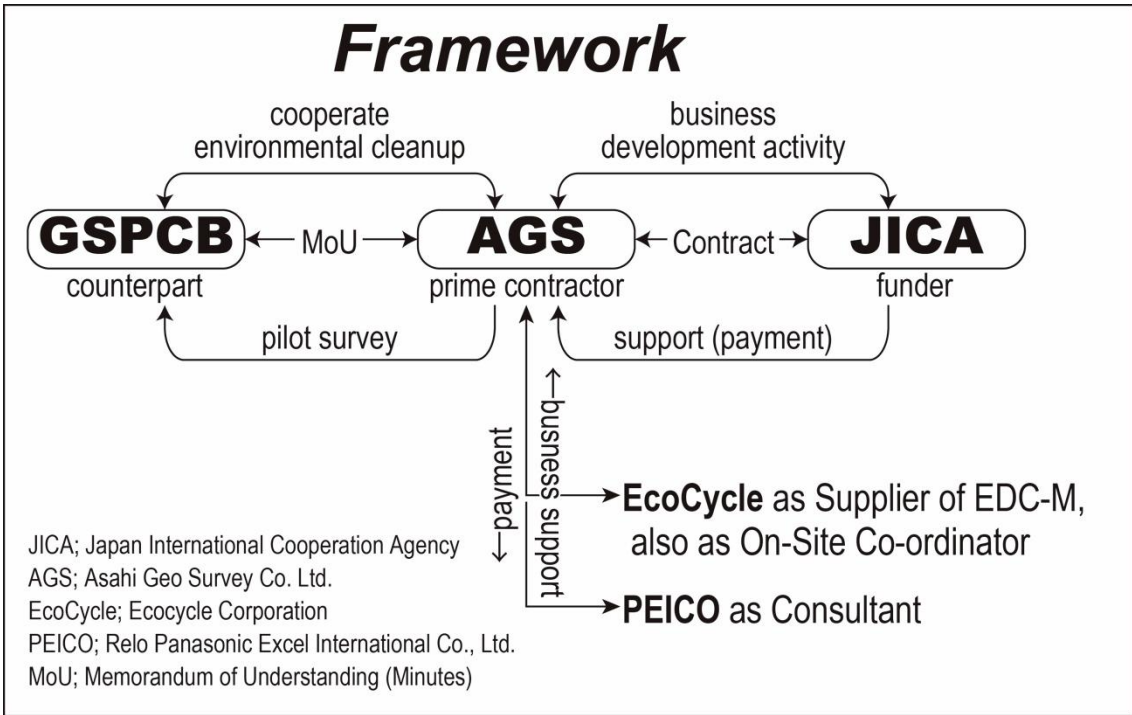


Figure 3 Implementation system

### 3. ACHIEVEMENT OF THE SURVEY

#### (1) Outputs and Outcomes of the Survey

Goa State had been aware of potential human health risks from both organic contaminants in the Sal River and illegal dumping in the Sal River basin (Cuncolim IDC). However, there was no data regarding the extent of hexavalent chromium or other heavy metal impacts for these areas, at the time this survey was commenced. As such, this survey started with Phase I and Phase II investigations to characterize the potential contamination in the target areas, and then remediation technologies were to be proposed based on the results of the Phase I and II investigations.

The Phase I and II investigations in the Sal River basin area identified: (a) organic groundwater contaminants from municipal, resort hotel and agricultural activities; (b) heavy metal groundwater impacts including mercury and lead from illegally dumped wastes at a former production facility (Sunrise Zinc plant); and, (c) abnormal pH levels in irrigation channels. However, no hexavalent chromium groundwater impacts were identified in this area.

The Bethora Industrial Estate investigations found hexavalent chromium concentrations in excess of 10 ppm and abnormal pH levels in water collected from irrigation channels, and it was suspected that groundwater in this area may be contaminated. However, no hexavalent chromium concentrations exceeded the standards in the subsequent soil and groundwater investigation.

Based on the results of the above investigations, AGS and GSPCB concluded that there was no evidence of significant hexavalent chromium groundwater contamination in the target areas. In accordance with the scope of work, AGS conducted a field demonstration using the integrated groundwater remediation unit and associated equipment. The remediation equipment was submitted to GSPCB and technical training regarding the effective use of the equipment was provided to GSPCB personnel.

A bench-scale treatability study confirmed the effectiveness of the biostimulant (EDC<sup>TM</sup>) in reducing hexavalent chromium levels in both groundwater and wastewater from a facility using hexavalent chromium from an approximate concentration of 10 mg/L to below the lower analytical quantification limit in a period of four weeks. Additionally, the laboratory study confirmed that ion-exchange resins reduced hexavalent chromium wastewater levels from 10 mg/L and that the photocatalytic device reduced hexavalent chromium solution levels from 1 mg/L to below the respective lower analytical quantification limits. The groundwater model

developed using Phase I data was also shown to accurately simulate the groundwater depth (5 m margin of error). The above studies confirmed the applicability of each technology in Goa State.

It should be noted that while no hexavalent chromium groundwater impacts were identified in either the Cuncolim or the Bethora Industrial Estates, the investigations revealed concentrations of the hazardous substances lead, mercury and cadmium exceeding the groundwater standards. It is recommended that GSPCB conducts periodic groundwater monitoring using the monitoring wells installed during this survey as part of Goa State's groundwater preservation activities.

Based on the fact that no significant hexavalent chromium impacts were identified during this survey, it can be presumed that the current scale of the hexavalent chromium groundwater remediation market in Goa is limited. However, Bethora Industrial Estate investigations revealed high hexavalent chromium concentrations in irrigation water and as such, there is a risk that groundwater in this area may be found to be contaminated in the future. Additionally, lead, mercury and cadmium concentrations exceeding the groundwater standards were identified in the investigations. This presents an opportunity to develop a remediation market targeting heavy metal groundwater contamination in the Bethora Industrial Estate area.

#### (2) Self-reliant and Continual Activities to be Conducted by Counterpart Organization

One of the purposes of this survey was to enable GSPCB to independently and sustainably continue groundwater investigations and groundwater conservation activities in Goa using both the physical equipment and technical guidance provided during this survey.

From a technical and organizational perspective, GSPCB management personnel were provided with seminars covering bioremediation techniques as well as site investigation and remediation theories and methodologies. The training also included practical fieldwork activities to reinforce the understanding of each methodological concept. On-site discussions were held with GSPCB management personnel, sampling technicians and IDC managers to improve the understanding of groundwater investigations and remediation for all participants. These training activities ultimately contributed to strengthening GSPCB environmental pollution control efforts.

To minimize the financial burden, locally-sourced materials were used when training GSPCB staff on the maintenance and repairs of the provided equipment. GSPCB technical staff was provided with hands-on equipment repair training using damaged or malfunctioning equipment to strengthen understanding.



Additionally, individual staff was designated responsibility for each piece of equipment to facilitate the appropriate utilization and maintenance of the equipment.

It can be concluded that the above activities have enabled GSPCB to proactively utilize and apply the provided equipment and techniques to conduct various measurements including composition testing of sludge and dust using the XRF analyzer and water quality testing for the Zuwari River using the multi-parameter water analyzer.

#### 4. FUTURE PROSPECTS

##### (1) Impact and Effect on the Concerned Development Issues through Business Development of the Product/ Technology in the Surveyed Country

This survey indicated that sanitary wastewater and dumped wastes appear to be the cause of an obvious reduction in water quality in Goa State waterways and that the resolution of this issue must be a priority for the State. This survey also confirmed that despite the introduction of regulatory measures (operation suspension, water quality monitoring, etc.) targeting polluters due to the evident environmental impacts, the existing regulatory framework does not provide clearly defined prevention measures or remediation guidelines. As such, this issue cannot be resolved as the discovery of contamination forces polluters into insolvency leaving contaminated 'brownfield' sites.

In order to resolve groundwater and other pollution issues, the establishment of a national regulation modeled on the 'Polluter Pays Principal' should be a priority for Indian lawmakers. Furthermore, corporations must be educated in order to enable them to prevent contamination before it occurs.

As the regulatory body responsible for pollution issues in Goa, the GSPCB should appeal to the State Government to establish more stringent standards as well as work to improve plant manager understanding of environmental investigation and remediation techniques. Considering that the majority of sanitary wastewater and waste issues can be sourced back to the local residents, the GSPCB should also make efforts to educate residents on improving and sustaining the environment.

##### (2) Lessons Learned and Recommendations

One of the main issues faced during this survey was the subdivision of project roles. For example, the task of sampling river water involves so many workers as (a) one person to collect the sample; (b) one person to prepare the sampling equipment; (c) one person to record the

sampling activities; (d) one person to perform environmental monitoring during the sampling activities; and, (e) one person to manage the sampling team. Even though respective wages are low, the large number of people to perform one task results in the costs similar to those in Japan. Moreover, the large staff numbers creates redundancy and increases the risk of inaccuracy and ineffective results. This will be the primary issue when developing the investigation and remediation businesses for soil and groundwater in India. If this issue can be resolved, it will have a significant effect in reducing costs.

Another issue encountered during this survey was the fundamental business nature of the boring industry in India. This includes the considerable difference in wages between the site manager and the workers and the lack of communication between them due to its wage disparity. This situation triggers high personnel turnover and investigation technology does not take root in the industry. Environmental drilling companies must endeavor to train their workers and ensure financial security and social status for their employees in order to establish a high level of boring skills in India.

ATTACHMENT: OUTLINE OF THE SURVEY

**Pilot Survey for Disseminating SME's Technologies  
for Groundwater Remediation by Bioremediation of the Sal River and Bethora Industrial Estate in Goa**

**Project and Site Information**

- Private Corporation: Asahi Geo Survey Co., Ltd. (AGS)
- Private Corporation Location: Tokyo
- Site Locations: Salcette region and Bethora Industrial Estate (Goa State)
- Counterpart Organization: Goa State Pollution Control Board
- Project Schedule: February 2014 to March 2016

●●● Development Issues In India ●●●

Aligned

●●● AGS Technologies / Products ●●●

➤ **Improving the environment**

The environmental cleanup policy in one of the pillars of the current Twelfth National Five-Year Development Plan (April 2012 to March 2017). The cleanup of brownfield sites is one of the main objectives but dumped wastes and groundwater contaminated by these wastes remain a serious issue.

➤ **Resolving human health impacts**

Groundwater use is prevalent in India and many people forced to consume groundwater contaminated by dumped wastes resulting in serious human health impacts .

**Biostimulant Groundwater Remediation Unit**

➤ **Biostimulant**

A nutritional supplement made from food material by EcoCycle Co., Ltd. (partner corporation). Functions to safely and reliably stimulate the natural breakdown of hexavalent chromium and other hazardous substances.

➤ **Pre-treatment technologies**

Consider technologies applicable for the site to reduce hexavalent chromium to the innocuous trivalent chromium form using photo catalysts  
 ⇒ The integrated groundwater remediation unit combines the above technologies to enable cleanup of varying concentrations and distribution

**Preparation by Private Corporation**

- Confirmed the state of groundwater contamination in the states of Goa and Karnataka in India through a 2012 Ministry of Foreign Affairs Verification Survey
- Established a cooperative relationship with the Goa and Karnataka State Pollution Control Boards and confirmed the need for groundwater remediation

**Overview of Private Sector Technology Promotion Project (JICA Project)**

- Technology Demonstration
  - Utilize pre-treatment technologies and biostimulant to conduct groundwater remediation in the targeted 'pilot' regions
  - Monitor and analyze groundwater remediation progress and provide hands-on training on such activities to counterpart organization
- Feasibility Study
  - Develop a business strategy to promote groundwater remediation based on market research, risk analysis, financing scheme surveys feasibility assessments.



**Business Development**

There are current plans for groundwater remediation project partnerships between the Indian Government and private corporations. The Indian Government has started the process of establishing a retroactively effective environmental law placing remediation responsibility on the polluter. The law will require companies operating plants that are the source of pollution to remediate the contamination. As a result, it is expected that the environmental remediation market will grow significantly.