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# **Assessment of Submarine Groundwater Discharge in** the Selected Coastal region of India

### Santosh Murlidhar Pingale, Sudhir Kumar, Ruchir Patidar, AB Bisht





GOVERNMENT OF INDIA

जल शक्ति मंत्रालय जल संसाधन, नदी विकास और गंगा संरक्षण विभाग MINISTRY OF JAL SHAKTI DEPARTMENT OF WATER RESOURCES. **RIVER DEVELOPMENT & GANGA REJUVENATION** 









**Hydrological Investigations Division** National Institute of Hydrology Roorkee 11<sup>th</sup> July, 2024

# Introduction

### ✓ Submarine Groundwater Discharge (SGD)

The hydrological process, where inflow of fresh and brackish groundwater occurs from land into the sea.

# How to detect & quantify SGD

#### ✓ Hydrologic Models:

Physical principles based on Darcy's law, water budget, hydrograph separation.

- Thermal measurements: Temperature contrast between groundwater and sea water.
- Seepage measurements: Capture water seeping into surface waters.
- Tracer Measurements: Naturally occurring tracers (radium/radon)



(Mulligan and Charette, pers.com)

Objective

To identify signatures of SGD using archival data of groundwater, thermal anomalies, hydro-chemistry, Radon & isotopic signatures based on field investigations (groundwater, seawater and porewater sampling) in the coastal aquifers.

### **Study Area**



### **Study Area**



### **Methodology**



## Methodology

#### **Data Collection**

- Archival data related with groundwater from different sources in the coastal aquifers of West Bengal
- Aquifer characteristics from CGWB reports & available literature.
- DEM (30 m spatial resolution), remote sensing datasets [Landsat 8 (thermal bands)] for the pre & post-monsoon season (year 2017, 2018 & 2019) have been downloaded and processed.
- Water samples [groundwater (bore well/hand pump), pore water, seawater] for chemical and stable isotope analysis have been collected in the study area.
- Seasonal groundwater table measurement data have been collected from CGWB.
- In-situ salinity & temperature measurement of pore water, groundwater & seawater water have been carried out for the study area.

## Methodology

#### **Data Collection**

- Water quality data related with pore water, groundwater and seawater have been collected.
- Water quality parameters & Radon concentrations have been measured in the field.
- Also, water samples have been collected and analyzed for the  $\delta^{18}O$  and  $\delta^{2}H$  isotope for selected locations.

### **Archival data collection**



Source: NBSS&LUP Regional Centre, Kolkata

Fine-Sandy Fine-Very Fine Sandy

### **Archival data collection**

 Collected archival data on groundwater levels from CGWB reports for the coastal districts of West Bengal



- Seasonal groundwater level analysis
- Detail analysis of δ<sup>18</sup>O, δ<sup>2</sup>H, Radon and water chemistry is done for the collected samples.
- Temporal plots of the isotopic composition of water samples & LMWL, GW– SWML & GMWL have been established using  $\delta^{18}O$  &  $\delta^{2}H$  of pore water, groundwater and sea water for the study region.
- Linkage between the isotopic signature of water, it's chemistry and hydrogeological processes is established and identified possible SGD zones in the study area.

#### **Groundwater table fluctuation**

#### 2017

#### **2018**



Groundwater level variation during pre & post monsoon season in Purba Medinipur

#### Groundwater dynamics based on archival data



### **Characterization of Aquifers**

 ✓ Collected archival data and compiled general aquifer characteristics from CGWB reports & literature available in public domain.

General characteristics of aquifers in coastal areas of West Bengal (Source: CGWB 2014)

Aquifer	Depth of wells (m)	Discharge of wells (m³/hour)	Drawdown (m)	Transmissivity (T) (m²/day)	Storativity (S)
Shallow	30-50	25-40	0.9-2.5	500-2000	03x10 <sup>-1</sup> to 0.5x10 <sup>-2</sup>
Deep	100-350	100-120	6-12	900-3000	03x10 <sup>-3</sup> to 1.1x10 <sup>-3</sup>

DISPOSITION O IN M150 10	F SUB-SURFACE FRESH COASTAL TRACT, WEST	H/SALINE AQUIRER BENGAL	Well location	Aquifer Depth range (m) bgl	Thickness Tapped (m)	Discharg e (lps)	Transmissivit y (m²/day)	Storactivity	Hydraulic Conductivity (m/day)	
			Upper Litho-system (Quaternary)							
DIAMO	NO HARBOUR MANDIR BAZAR	BASANTI	Negua	20-57.5	14	13.6	1700-2500	4.2-7.7x10 <sup>-3</sup>	18	
D	URGACHAK	COSAGA	Daspur	45-157	27	44.15	3800	$3.8 \mathrm{x} 10^{-5}$	34	
HATIE	SERIA O		Jalchak	47-65	18	14	700-800	$5.7 \mathrm{x} 10^{-4}$	43	
1.			Lower Litho-system (Tertiary)							
KATKADEVICHAK MUKUNDPUR			Negua	101-200	47.5	65.01	3700-4500	1.1x10 <sup>-3</sup> - 8.3x10 <sup>-4</sup>	45	
KANTHI			Kapasariya	240-346	28	28.39	300	$4.9 \mathrm{x} 10^{-5}$	3	
ICHABANI		20 121	Jalchak	143-164	21	61.7	1800	$1.3 x 10^{-4}$	84	
	CLAY FINE SAND	MEDIUM SAND	Haldia	187-202	12	25.3	800		34	
	COARSE SAND	GRAVEL	Khejuri	234-291	30	53.44	2400-2800	3-6.8x10 <sup>-4</sup>	43	
s		FRESH GROUND WATER	Sarasankha	79-220	48	44	2400-3500	1.1x10 <sup>-2</sup> - 8.1x10 <sup>-3</sup>	72	

Disposition of aquifers in the coastal tract of West Bengal (Source: CGWB, 2014)

### **Thermal Anamolies**

Path/Season	Path 138 Row 45	Path 139 Row 45
2017 Pre-monsoon	14 April 2017	7 May 2017
2017 Post-monsoon	23 October 2017	14 October 2017
2018 Pre-monsoon	17 April 2018	10 May 2018
2018 Post-monsoon	26 October 2018	17 October 2018
2019 Pre-monsoon	6 May 2019	27 April 2019
2019 Post-monsoon	29 October 2019	20 October 2019

### Landsat 8 remote Sensing datasets







### **Field data analysis**

- ✓ Collected water samples [groundwater (bore well/hand pump), pore water, seawater] for chemical, stable isotopes ( $\delta^{18}$ O and  $\delta^{2}$ H) & Radon analysis from the coastal district of Purba Medinipur.
- ✓ Carried out in-situ measurements for salinity and temperature of pore water, groundwater, and seawater water for the selected locations in the Purba Medinipur district.



SN	Samples	Water Quality	Isotopes	Radon	Total
1	Groundwater	22	19	16	
2	Seawater	12	12	10	
3	Porewater	7	8	6	
4	River water	6	5	2	
	Total	47	44	34	125



### **Sediment Porewater sampler**





Water sample collection during field visit at coastal districts of Purba Medinipur during Feb 2020

#### Physiochemical characteristics of the coastal areas of Purba Medinipur

		Parameters									
SN	Statistics							δ <sup>18</sup> Ο	δD	Rac	lon
		P <sup>H</sup>	Temp. (°C)	EC (µs/cm)	DO (ppm)	Salinity (psu)	Elevation (m)	(‰)	(‰)	Mean (pci/l)	SD (pci/l )
1					Groundwa	ter					
	Min	7	20.93	652	0.2	0.31	2	-5.5	-37.2	2.77	2.26
	Max	7.9	30.7	<b>2943</b>	4.68	153	15	-2.7	-15	63.9	15.9
	Average	7.4	27.38	1080	1.54	7.42	7	-3.5	-22.7	35.1	9
2	Seawater										
	Min	7.9	18.95	6800	3.45	3.76	0	-5.2	-36.5	1.94	2.24
	Max	8.9	28.2	31230	9.73	19.45	10	-0.8	-8.59	14.6	9.47
	Average	8.2	22.84	24325	5.69	15.02	3	-2.4	-18.3	8.11	3.88
3					Pore wate	er					
	Min	6.9	21.17	8666	0.61	0	0	-4.2	-30.3	1.95	3.89
	Max	8.2	25.1	32830	4.21	20.64	4	-0.5	-3.29	54.9	14.9
	Average	7.7	22.96	18658	1.96	10.1	2	-2.7	-19.8	33.6	10.9
4					River wat	er					
	Min	7.5	20.74	647	2	0.32	2	-6	-43.1	4.16	1.6
	Max	8.2	24.7	70050	8.63	19.05	6	-1.1	-11.7	4.16	2.77
	Average	7.9	21.83	19672	6.29	6.31	4	-4.8	-34.7	4.16	2.19





EC, TDS and Radon variation in water of along coast line of Purba Medinipur

Isotopic characteristics of waters along coastline



Signatures of SGD and SWI in coastal district of Purba Medinipur



Note: Groundwater (HP, BW), Porewater (PW), Seawater (SW) & River water (RW)

#### pH of different water sources along the costal line of Purba Medinipur



EC, TDS & temperature variations along coastline of Purba Medinipur District



EC and salinity variation along costal line of Purba Medinipur District



## **EC of groundwater**

### **SGD** potential zone identification

Processed DEM (30m), Landsat 8 Burdwan (thermal bands datasets for the Ranaghat Mem an pre & post-monsoon (year 2017, Bangaon 2018 & 2019). Temporal plots of the isotopic Arambag Hugli composition of water samples and Habra LMWL, GW-SWML & GMWL have Barrackpur North wanty Sa & been plotted established Ghatal Basirhat relationships using  $\delta^{18}O$  &  $\delta^{2}H$  of porewater, groundwater & seawater. Linkages between the isotopic R ipur signature of water, its chemistry, & hydrogeological processes is Diamond South Harbou established for the identification of Purba ledinip possible SGD zones in the study area. Signature SGD & SWI locations were identified. Purb.a 21°30'0"N Legend 510 30 20 SWI Possible SGD Zones SGD Sources: Esri, HERE, Garmin, Intermap, increment P Corp. GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Sampling\_locations Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), C OpenStreetMap contributors, and the Coastal districts **GIS User Community** 88°0'0"E 89°0'0"E 87°30'0"E 88°30'0"E

Possible zones of SGD & SWI in coastal regions of West Bengal

# **Conclusions & Recommendations**

#### Conclusions

- The coastal region of West Bengal has a variety of geomorphological units and landforms which comes under Purba Medinipur, South and North 24 Parganas & Howrah district.
- ✓ In this region, alluvium of Recent to Pliestocene ages & Tertiary sediments form the aquifers. Each aquifer system comprises one or several interconnected aquifers.
- Quality of groundwater in coastal aquifers of West Bengal varies considerably and in a major part of the coastal tracts water is potable.
- In general, most of the groundwater samples are alkaline nature. Some places salinity is high as well as groundwater contamination occurs which may be due to anthropogenic activities in the coastal areas.
- There are primarily four SGD zones can be suspected along the coastal tract of Purba Medinipur based on field investigations, water quality, groundwater levels and isotopic analysis.
- There are six SGD zones can be primarily suspected in case of coastal line of Howrah, South- and North 24 Parganas district. However, it needs detailed field investigations where the results are based on thermal anomalies and groundwater levels.

# **Conclusions & Recommendations**

#### Recommendations

- ✓ It is recommended that the proper provision of rainwater harvesting & groundwater recharge schemes can be implemented in the possible SGD zones and its catchment areas where the sustainable fresh groundwater can be obtained in the coastal regions.
- ✓ It is also recommended that additional field visits can be made in the identified SGD zones and detail investigation can be initiated for development & tapping of fresh groundwater resources in the study region.

#### Limitations

- Field data collection was not able to carried out exactly at 1 km due to local conveyance and adverse field conditions. Also, additional field visits have not been carried out in the study area due to COVID-19 pandemic.
- In addition, there are restrictions in the coastal areas of North & South 24 Pargana where the area is dominated by mangrove areas (Sundarbans Forest).
- These limitations may result slight differences in the actual estimates of the possible SGD zones where analysis is solely based on analysis of thermal imageries & archival groundwater data. This has to be taken into consideration.

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#### Contact: Dr. S. M. Pingale, Scientist-D, HI Division, NIH Roorkee

Email: pingalesm@gmail.com; pingalesm.nihr@gov.in http://scholar.google.co.in/citations?hl=en&user=nzL9Z8EAAAAJ

