ASSESSING THE SALINITY INTRUSION EFFECT OF RIVERS AND COASTAL AREA OF BANGLADESH USING STATIC AND DYNAMIC WATER SALINITY DATA OF VARIOUS LOCATIONS

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ABSTRACT

Bangladesh is a riverine country with hundreds of rivers and one-third of the total land is covered by the coastal zone. In the coastal area, Khulna and Barishal regions are the most affected area compared with other zone in case of salinity issue. Surface water is commonly used in agriculture so measuring the intensity of saline in rivers is very important. Main objective is to finding out the salinity in main rivers in different positions is helpful to understand the effect of distance from the sea & Discharge and as study over the 2 years is helpful to predict the future. Apart from that, this study is helpful in comparing both regions in the case of salinity. In this study, mainly Krittonkola and Boleshar rivers in Barishal region and shibsha & poshur rivers in the Khulna region have been selected where these rivers are connected with the Meghna & Padma Rivers respectively upstream and the Bay of Bengal downstream. For the Static salinity test, samples were collected from selected rivers at different scheduled times. However, Dynamic Salinity water samples were collected from 35 stations at Bardia to Hiron Point in Nabaganga, Rupsa & Pasur rivers and back through Sibsa river from Hiron Point to Khulna by using a ship and bucket with rope. These samples were collected during dry season at the full moon or new moon time. Salinity analyses are being performed using Aquaread water monitoring instruments & CyberScan CON11. salinity in both Electrical Conductivity (EC) & PSU scale of collected dynamic water samples and only EC for static samples are being observed here. On the other hand, discharge has been taken by using Acoustic Doppler current profiler (ADCP).It is observed that Salinity intrusion has been increasing every year. Due to high discharge of water from upstream, salinity is less affected in Barishal zone in comparison with Khulna zone. Salinity issues may be reduced by increasing discharge of water from upstream.

Keywords: *Salinity intrusion, coastal area, water quality, discharge, adcp*

1. INTRODUCTION

Bangladesh is a deltaic country located at the confluence of the world's three largest rivers, the Ganges, Brahmaputra-Jamuna, and Meghna. Bangladesh is a riverine country with hundreds of rivers overlaying its landscape & situated near the Bay of Bengal where a total area of 147,570 km^2 including 29,000 km^2 of the coastal region. However, more than 30% of the cultivable land is covered by coastal and offshore areas (Haque, 2006). Salinity conquered land furthermore increased many folds due to climate change and its driven catastrophic hazards like sea level rise, cyclones, and storm surges (Anik and Khan, 2012). Due to these reasons, coastal areas especially in the south and south-western regions are highly affected by salinity intrusion through surface water and its increasing day by day. Increasing salinity is a crucial issue for the people of the coastal region of Bangladesh. Due to increasing salinity in the water and soil, the people of the region are suffering from scarcity of safe drinking water, irrigation, agriculture, and other uses. Ecology of the coastal region especially in the southwest region is greatly concerned with salinity. A recent study indicates that 93 sub-districts (upazilla) of 19 districts are facing salinity issues where 10.56 lakh hectre are affected out of 28.5 lakh hectre which is around 33% of total land in coastal region (Soil Resource Development Institute, 2010) [1]. (Fig.1)

However, it has been observed that all the coastal cultivable lands are not being utilized for crop production, mostly due to soil salinity. Increased soil salinity limits the growth of standing crops affects overall crop production, and also makes the soil unsuitable for many potential crops. Soil salinity has been considered a major constraint to food grain production in coastal areas of the country.
Salinity intrusion occurs mainly through surface water. In this study mainly observed the dynamic salt intensity in different rivers (i.e. Nabaganga, Rupsha-Passur & Shibsa) at various positions in the Khulna region over the past 3 years. On the other hand, static salinity was observed in Barishal-Buriswar, Biskhali, and rivers in Barishal region and Rupsha-Passur & Shibsa at Khulna region. In both regions, all of these rivers are connected upstream. To develop a relation between discharges from upstream with salinity, the discharge has taken in the same river.

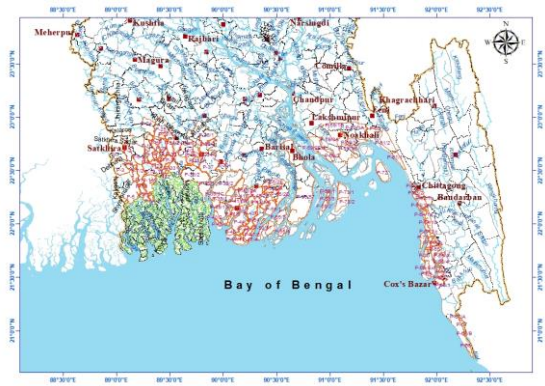

Figure 1: Coastal Area of Bangladesh

This article mainly narrates an overview of both regions over the past 3 years. Data analysis of static and dynamic salinity and discharge over the past years will help understand the real scenario and as well as useful in predicting the future of coastal areas.

2. METHODOLOGY

2.1 Study Area

The salinity issue is crucial in coastal areas and it's increasing every year. In this study, the Coastal zone at Barishal and Khulna is selected for the study. Barishal division is located between 22°04' and 21°48' north latitudes and between 90°10' and 90°12' east longitudes. On the other hand, the Khulna division is located between 22°04' and 21°48' north latitudes and between 90°10' and 90°12' east longitudes. Both regions are affected by salinity through surface water, so the main rivers of those zones were selected to understand the scenario. In this study, static and dynamic salinity measurements have been performed over the past 1 and 3 years respectively. **Figure 2** shows the map of the study area.

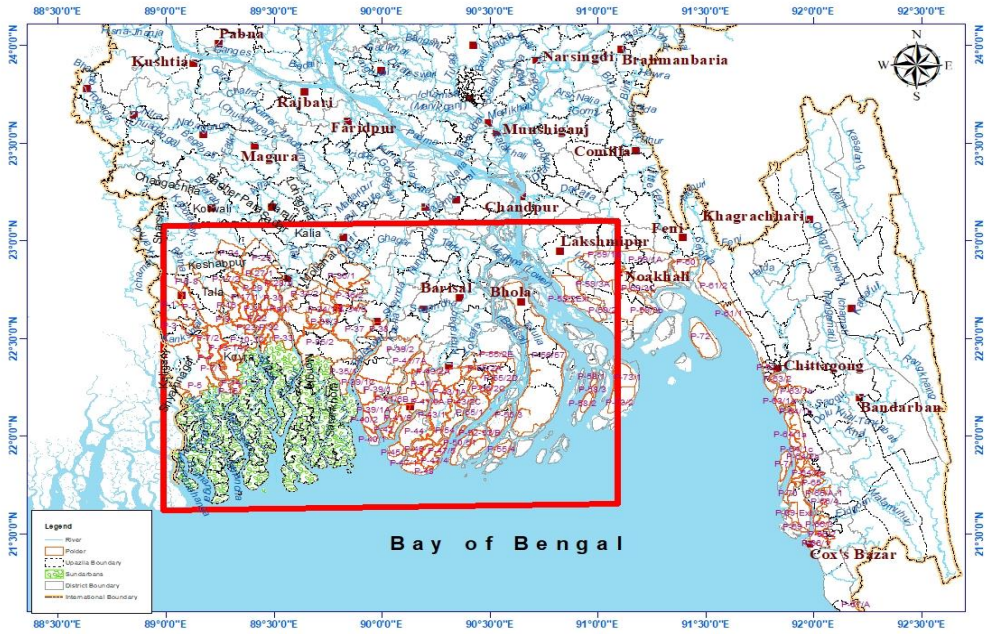

Figure 2: Study Area

2.2 Dynamic Salinity

Dynamic Salinity water samples were collected from 33 stations at Bardia to Hiron Point in Nabaganga, Rupsa, and Pasur River (Fig.3). These samples were collected once a hydrological water year in the dry season during the full moon or new moon by using a ship and bucket.

Figure 3: Location of Dynamic Stations (33 Nos)

Salinity analyses have been performed by using the device Aquaread water monitoring instruments or Cyber Scan con-11 conductivity/TDS meter. Electric conductivity (E.C.) and salinity in PSU (Practical Salinity Unit) of collected water samples are being observed here. This study was performed over the last 3 years (2021, 2022 and 2023)

2.3 Static Salinity

Static Salinity analysis of water samples collected from 12 (Twelve) stations (Fig.4) of different rivers in South- Western part of Bangladesh are being performed through. These water samples were collected monthly from January 2022 to December 2022. At Khulna water samples were collected from three locations (Chalna, Mongla, and Khulna) of the Rupsa- Pasur River, and on the other hand, samples were collected from 9 locations of 3 rivers (Bishkhali, Barishal-Burishar whose local name is Payra and Tetulia) at Barishal zone (Table-2).

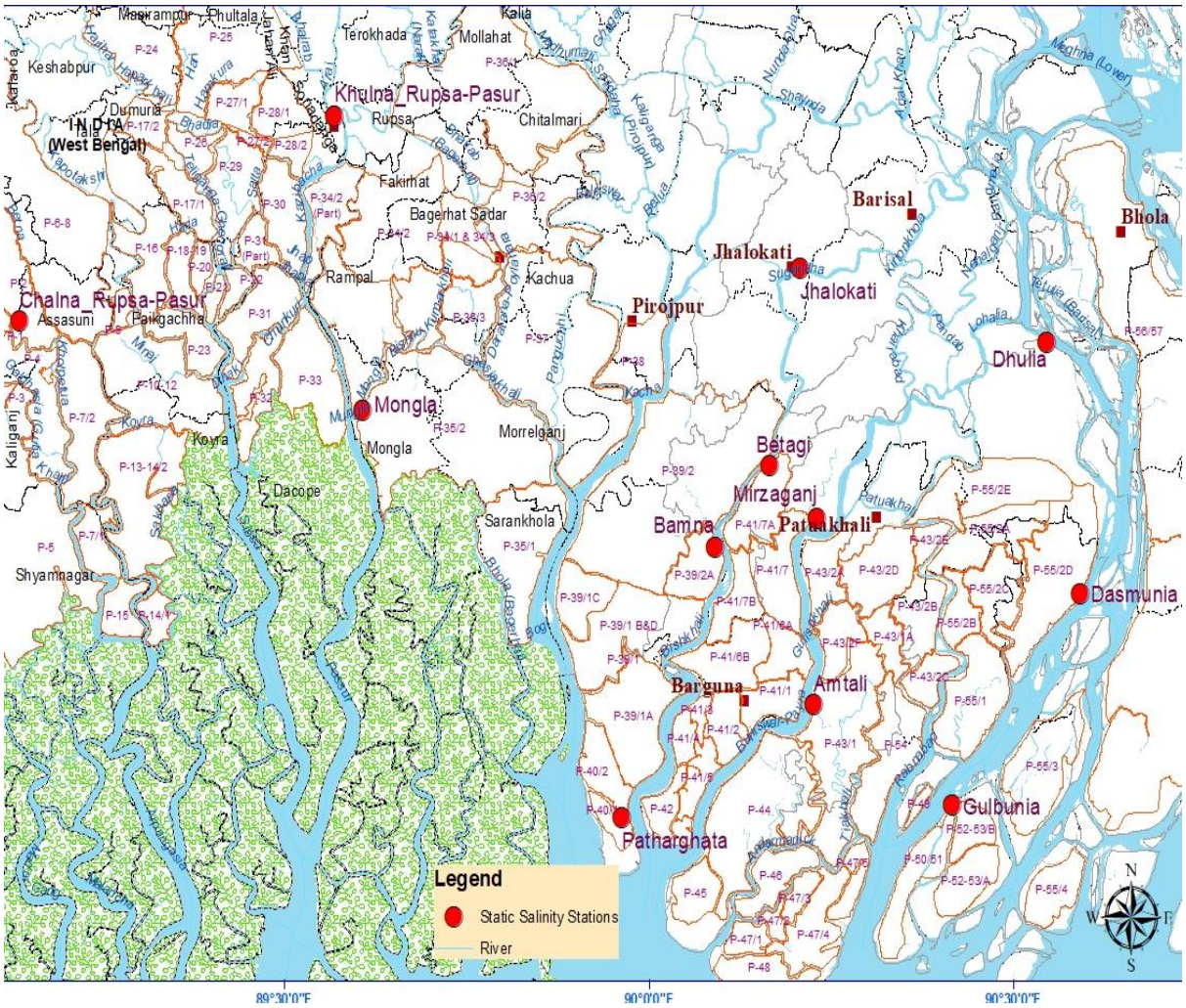

Figure 4: Location of Static Stations (12 Nos)

2.4 Discharge Measurement

Discharge measurements have been taken at the Kirtankhola and Baleswer Rivers in Barishal region and Rupsha-Pashur River in the Khulna zone. All measurements had taken bi-weekly by using ADCP and due to tidal flow this measurement has taken at hourly intervals but only the highest discharge value was taken in cum/sec. During discharge measurement, water samples were collected for salinity tests to understand the effect of water discharge on salinity.

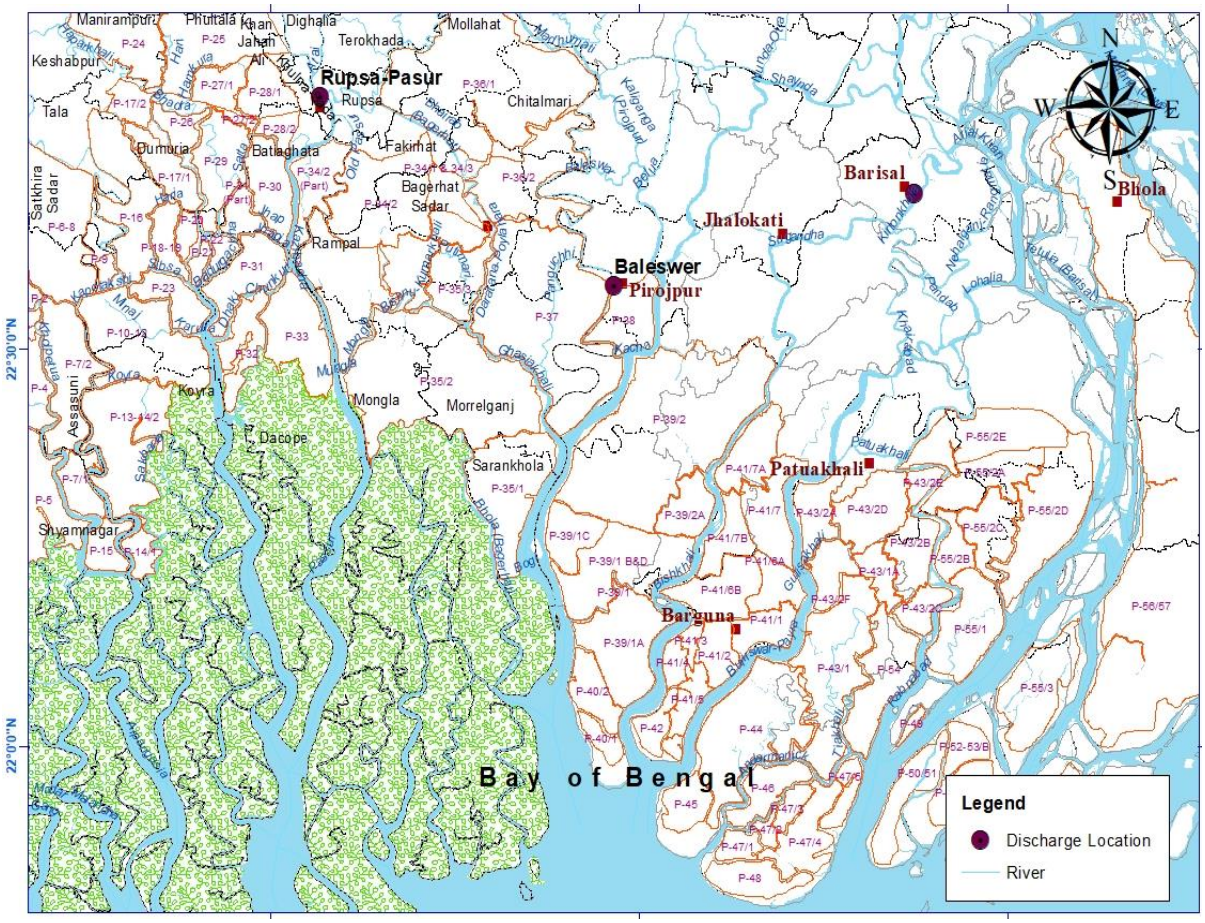

Figure 5: Location of Discharge Stations (3 Nos)

3. RESULT AND DISCUSSION

3.1 Result Analysis of Dynamic Salinity

3.1.1 Dynamic Salinity Comparison of Different Locations at Nabaganga and Rupasha-Passur Rivers and Effect of Distance from Sea

The EC of water is an indicator of salinity and hazard that gives the total salt concentration in water (Brady and Well, 2002) [4]. Water samples were collected from different locations of Nabaganga, Rupasha-Passur Rivers. By using GPS locations were recorded and also measure the distance from sea by using Google Maps. Every year samples were taken from the same location which is useful for understanding the change in salinity intrusion intensity over 3 years.

According to DoE the EC of effluent should be below 1200 µ/cm (Doe (1997) Department of Environment, Bangladesh Gazette, No. Da-1; Ministry of Environment and Forest. 1324-1327) [5]. From Figure-6 and 7 of dynamic salinity, it is very clear that salinity intensity has been increasing from 2021 to 2023. On the other hand, these figures also show salinity intensity for three consecutive years (2021, 2022 &2023) with distance from the sea. Values of salinity have been decreasing by increasing distance from the sea and the maximum value is shown near the sea and the minimum value is shown at Nabaganga River.

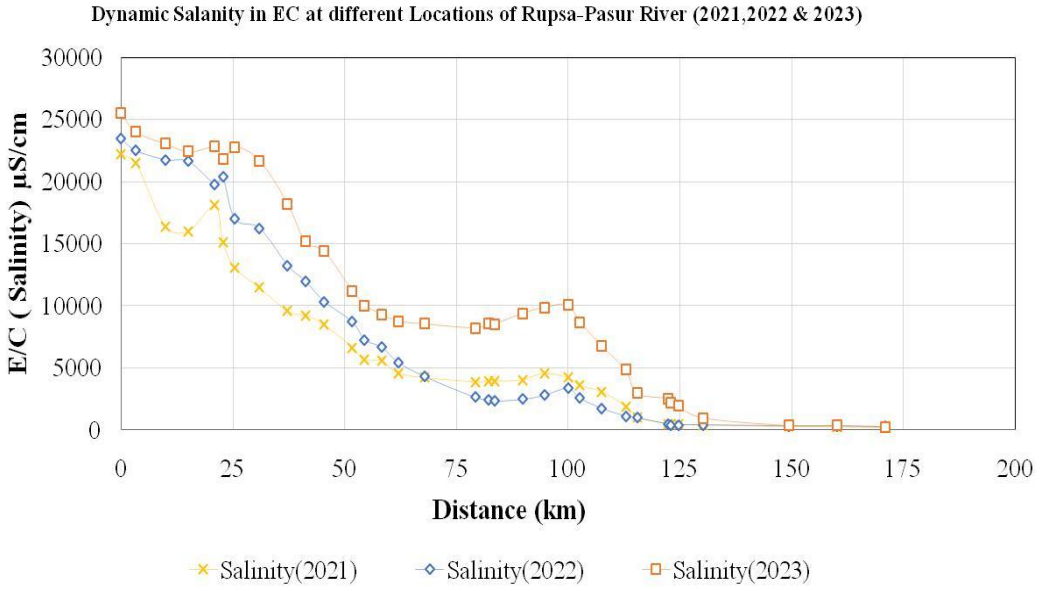

Figure-06: Dynamic Salinity (EC) Graph respect with Sea Distance

In 2022 from a distance of 75KM salt intensity has decreased and every year it is increasing. To analyze the reason rainfall data was collected on the same day of collecting samples and found that around 50mm of rain rainfall was recorded in the Khulna region. Due to the increase of salt-free water from rain salinity has decreased in 2022 for certain areas of surface water.

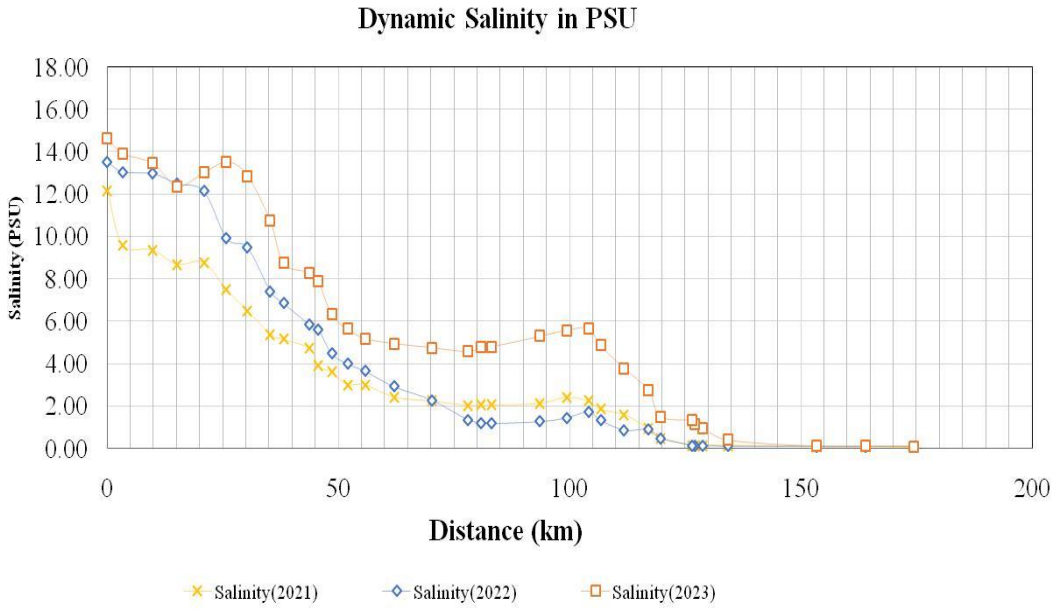

Figure-07: Dynamic Salinity (PSU) Graph respect with Sea Distance

3.1.2 Dynamic Salinity value of three (3) years in Tables

Water salinity was measured in both EC and PSU units from 2021 to 2023 which is shown in Table 1. From this table and analysis of EC value, it's clear that salinity has been decreasing by increasing distance from the sea, and before km 120 salinity has exceeded the acceptable limit.

Table 1: Dynamic Salinity Data of different locations at Khulna Zone

SL No.	River Name	Distance from Sea (km)	Electrical Conductivity (E C)			Salinity in PSU		
			2021	2022	2023	2021	2022	2023
01	Nabaganga	170.91	198	299	256	0.060	0.090	0.080
02	Nabaganga	160.2	258	311	353	0.080	0.100	0.110
03	Nabaganga	149.41	295	321	368	0.090	0.100	0.120
04	Rupsha-Passur	130.07	412	391	971	0.130	0.120	0.410
05	Rupsha-Passur	124.6	460	405	1956	0.140	0.130	0.970
06	Rupsha-Passur	122.96	461	419	2230	0.150	0.130	1.130
07	Rupsha-Passur	122.27	489	466	2522	0.150	0.150	1.330
08	Rupsha-Passur	115.41	1017	1010	2946	0.480	0.480	1.510
09	Rupsha-Passur	112.88	1908	1106	4874	0.940	0.910	2.730
10	Rupsha-Passur	107.42	3081	1752	6803	1.600	0.870	3.770
11	Rupsha-Passur	102.55	3577	2576	8692	1.870	1.320	4.870
12	Rupsha-Passur	99.98	4243	3356	10050	2.250	1.740	5.680
13	Rupsha-Passur	94.71	4580	2802	9855	2.430	1.440	5.580
14	Rupsha-Passur	89.73	4018	2502	9378	2.123	1.280	5.300
15	Rupsha-Passur	83.51	3956	2347	8520	2.070	1.190	4.800
16	Rupsha-Passur	82.19	3941	2394	8555	2.080	1.200	4.780
17	Rupsha-Passur	79.19	3867	2632	8221	2.030	1.350	4.570
18	Rupsha-Passur	67.91	4229	4284	8543	2.240	2.270	4.740
19	Rupsha-Passur	61.93	4594	5449	8760	2.420	2.930	4.940
20	Rupsha-Passur	58.36	5568	6665	9294	3.010	3.650	5.190
21	Rupsha-Passur	54.38	5636	7269	10010	3.000	3.990	5.640
22	Rupsha-Passur	51.66	6620	8715	11180	3.620	4.480	6.330
23	Rupsha-Passur	45.39	8495	10320	14380	4.730	5.840	8.300
24	Rupsha-Passur	41.21	9224	12000	15160	5.150	6.860	8.740
25	Rupsha-Passur	37.17	9570	13230	18200	5.370	7.410	10.730
26	Rupsha-Passur	30.91	11460	16220	21660	6.490	9.490	12.860
27	Rupsha-Passur	25.41	13030	16970	22760	7.500	9.920	13.520
28	Rupsha-Passur	22.77	15140	20380	21780	8.780	12.150	13.010
29	Rupsha-Passur	20.92	14960	20930	20760	8.690	12.510	12.370
30	Rupsha-Passur	15.02	16010	21620	22400	9.370	12.970	13.470
31	Rupsha-Passur	9.89	16380	21730	23050	9.590	13.050	13.920
32	Rupsha-Passur	3.28	21460	22490	24013	12.170	13.520	14.650
33	Rupsha-Passur	0	22170	23440	25480	13.330	13.890	15.360

3.2 Analysis of Static Salinity

Water samples were collected from a total of 12 stations of different rivers at the Khulna and Barishal zones during highest and lowest water level.

Table 2: Static Salinity station location with distance from sea

SL No.	Station Name	Chanel	Zone	Location		Distance from Sea (km)
				Longitude	Latitude	
01	Jhalokati	Bishkhali	Barishal	90.20760	22.64322	106.07
02	Betagi	Bishkhali	Barishal	90.16617	22.41700	73.20
03	Bamna	Bishkhali	Barishal	90.09078	22.32414	60.77
04	Patharghata	Bishkhali	Barishal	89.96345	22.01332	14.77
05	Dhulia	Tetulia	Barishal	90.54654	22.55818	99.59
06	Dasmunia	Tetulia	Barishal	90.59233	22.27064	62.11
07	Mirzaganj	Barishal-Buriswar	Barishal	90.23090	22.35651	57.72
08	Amtali	Barishal-Buriswar	Barishal	90.22652	22.14320	33.50
09	Gulbunia	Barishal-Buriswar	Barishal	90.41594	22.02784	22.70
10	Khulna	Rupsa- Pasur	Khulna	89.56811	22.81788	126.41
11	Mongla	Rupsa- Pasur	Khulna	89.60798	22.48066	83.07
12	Chalna	Rupsa- Pasur	Khulna	89.13667	22.58281	22.81

3.2.1 Data analysis by maximum value

Three (3) channels (Bishkhali, Tetulia & Barishal-Buriswar) have been selected in the Barishal Zone, whereas only one channel in Khulna i.e. Rupsa-Pasur has been selected. From Table 3 which shows the maximum value of EC of 12 stations in 2022, it is clear that Rupsa-Pasur contains the highest salinity compared with the other 3 rivers, and in comparison, only Barishal Zone Tetulia River carries more salinity considering the same distance from the sea.

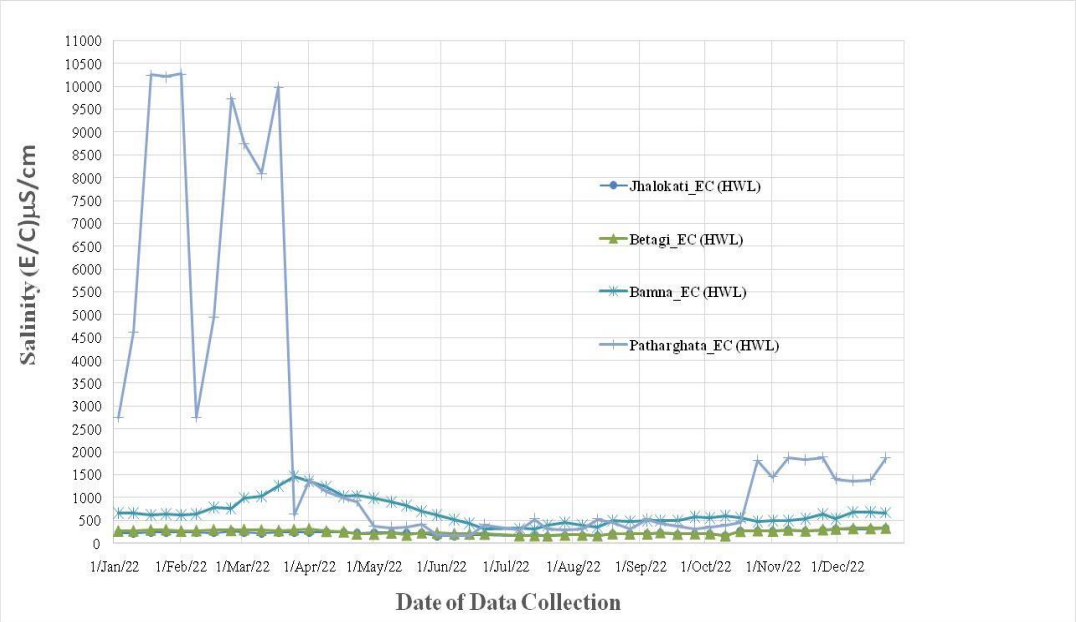

Figure 8: Static Salinity at 4 stations of Bishkhali River in 2022

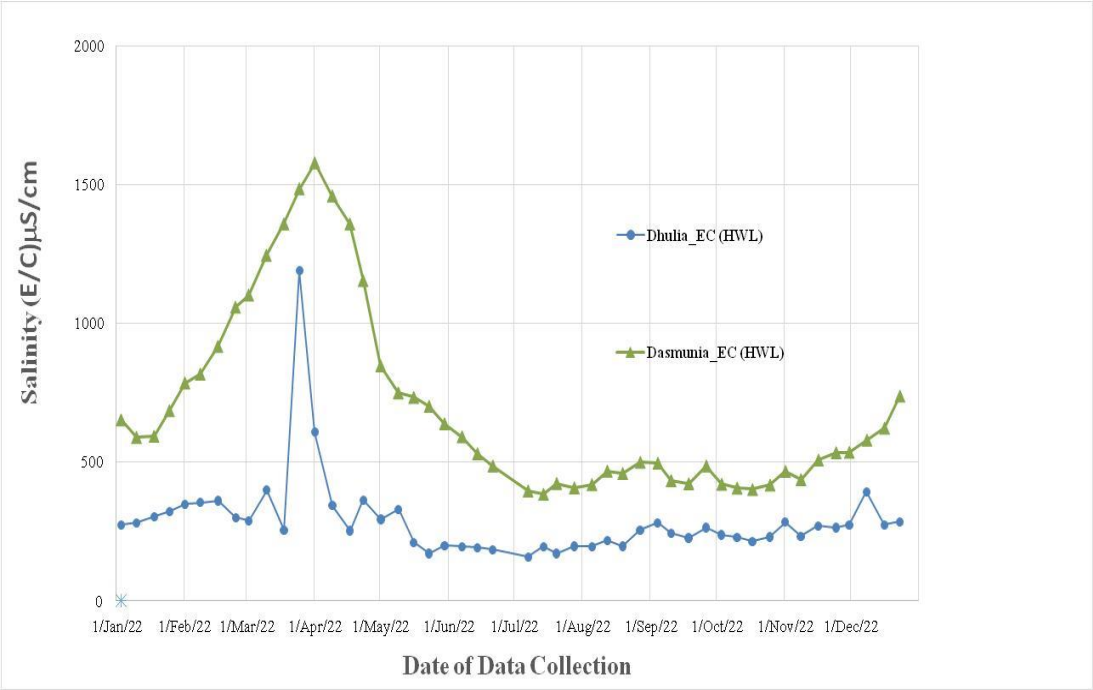

Figure 9: Static Salinity (EC) at Different Location of Tentulia Channel (January,22 to December,22)

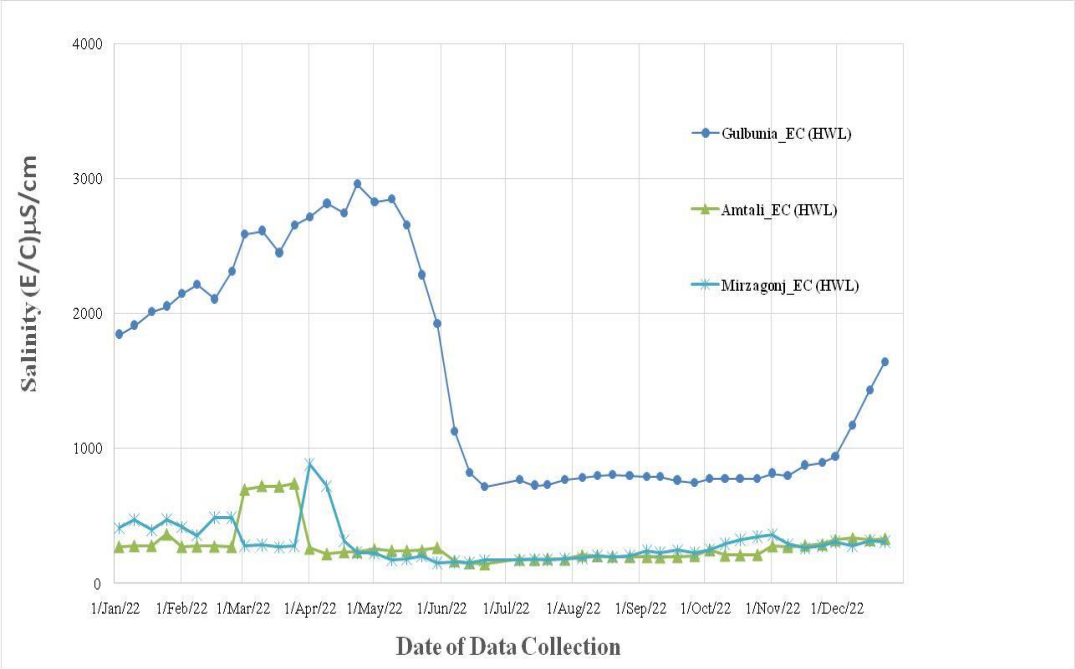

Figure 10: Static Salinity (EC) at Different Locations of Barishal-Buriswar (January, 22 to December, 22)

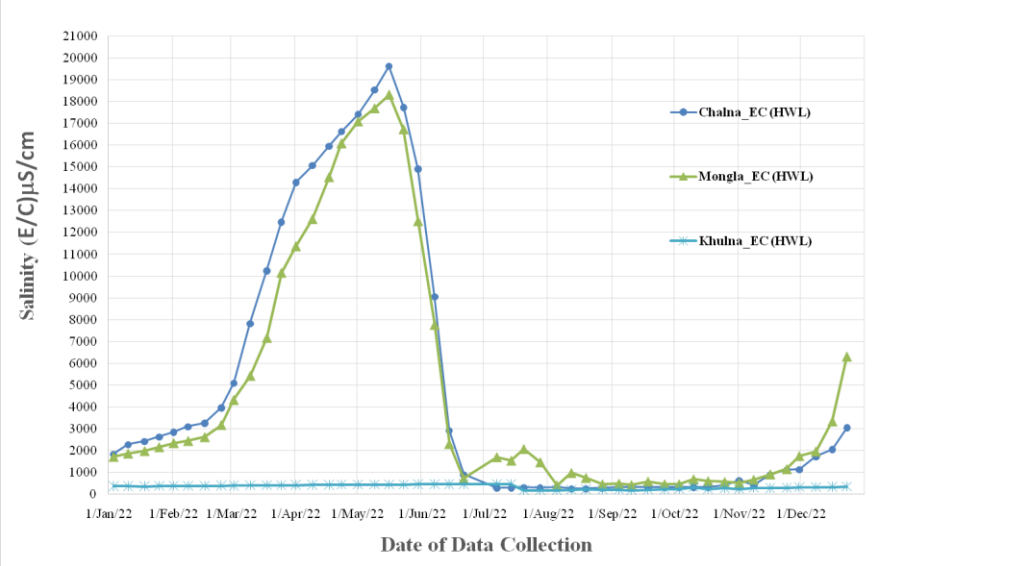

Figure 11: Static Salinity (EC) at Different Location of Rupsa-Pasur Channel (January,22 to December,22)

Table 3: Maximum Value of Static Salinity Data at selected location of study area

SL No.	Station Name	Distance from Sea (km)	Electrical Conductivity (E C) µS/ Cm	
			Highest	Lowest
01	Jhalokati	106.07	358	147
02	Betagi	73.20	339	147
03	Bamna	60.77	1452	298
04	Patharghata	14.77	10520	173
05	Dhulia	99.59	1190	151
06	Dasmunia	62.11	1578	384
07	Mirzaganj	57.72	882	147
08	Amtali	33.50	737	139
09	Gulbunia	22.70	2961	684
10	Khulna	126.41	458	170
11	Mongla	83.07	18329	389
12	Chalna	22.81	19618	247

3.3 Discharge effect on salinity

To understand the scenario of salinity all over the year due to changing water discharge, discharge, and salinity measurements were taken at the same time. The experiment was performed bi-weekly from January to September of 2022. Figure 12, 13, and 14 shows the value of discharge at every station and found that discharge had fluctuated. On the other hand, due to the tidal effect, there is no significant effect or relation of discharge on salinity is found, so a discharge station should be selected upstream where the tidal effect is absent.

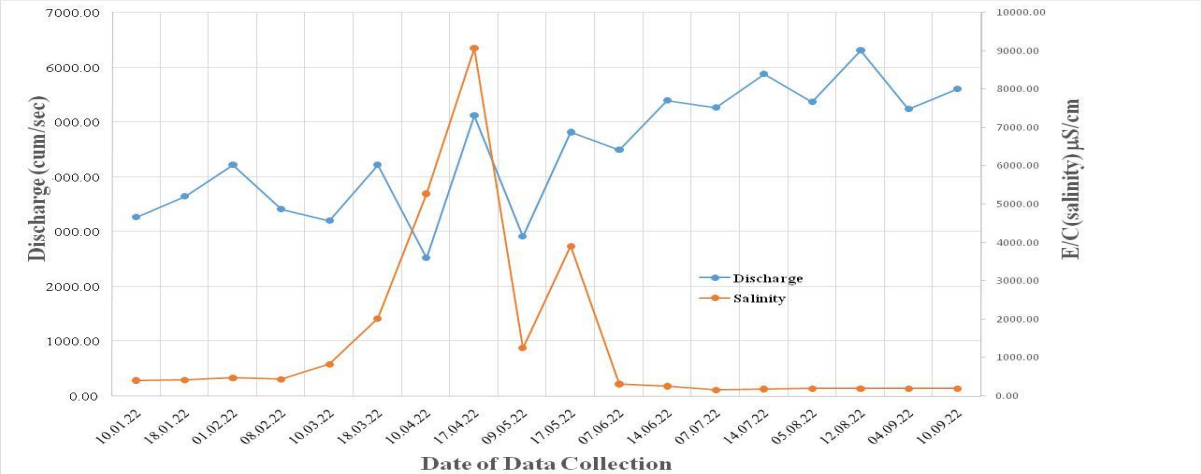

Figure 12: Discharge and Salinity at Khulna of Rupsa-Pasur River in 2022

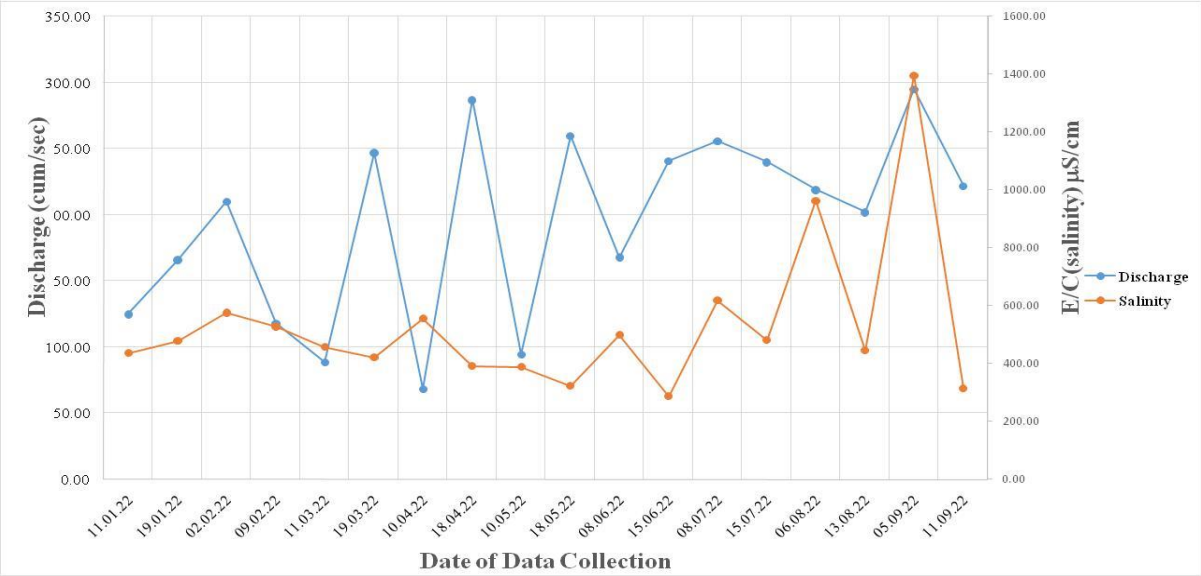

Figure 13: Discharge and Salinity at Pirojpur of Baleswer River in 2022

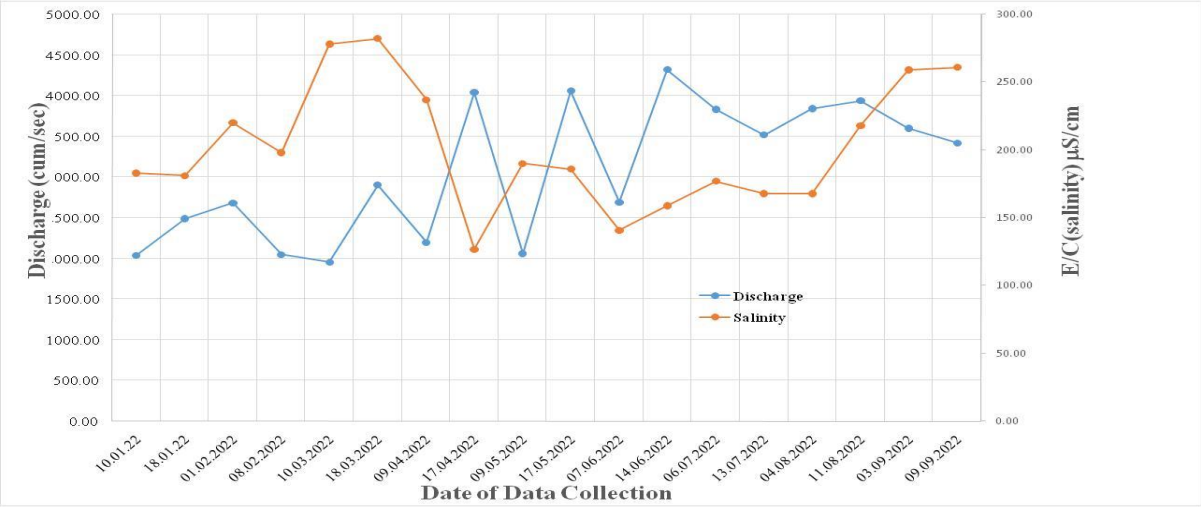

Figure 14: Discharge and Salinity at Barishal of Kirtonkhola River in 2022

4. CONCLUSION

Figure 13: Discharge and Salinity at Pirojpur of Baleswer River in 2022

5. CONCLUSIONS

From this study, it is observed that Salinity intrusion has been increasing every year. Due to the high discharge of water from upstream, salinity is less affected in the Barishal zone in comparison with the Khulna zone. Salinity issues may reduced by increasing the discharge of water from upstream. When the distance from the sea is increasing the salinity effect is decreasing or vice versa.

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