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Assessment of Drinking Water Quality and its Effects on Health from Mongla City with Surrounding Area of Bangladesh

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ABSTRACT

Mongla City in the southern part of Bangladesh is facing problems with the scarcity of suitable drinking water. The present study is to identify the suitability of the geochemical property of groundwater for drinking purposes. The water samples from 24 Tub-wells, Tab water, and other drinking water sources have been collected. The main purpose is to assess the groundwater arsenic and salinity hazard in Mongla City and its surrounding area. The pH value of drinking water in the study area ranges from 6.7 to 7.38 with an average value of 7.09, which is within the permissible limit for drinking uses. The TDS values range from 95.96-to 1365.60 mg/l. The EC and TDS values fall within the drinking water quality standard. According to WHO, the Arsenic contamination ranges between 0 ppb – 335 ppb which is within the permissible range of the Bangladesh Arsenic Standard (<50ppb). All the Cations and Anions are within the permissible limit of the drinking uses except the Na+ concentration is slightly higher with an average value being 203.36 mg/l. The people in the Rampal area get safe drinking water within 50m far away from their house and some are very near to their houses. Mongla city is located very near to the coaster hence few deep tubes are well found and high salinity intrusion is unsuitable for drinking purposes, Most of the time, they had to buy safe drinking water from NGOs or GO controlled companies. Very few people use Tap water and pond water for drinking purposes. The Groundwater of the study area is slight to moderate and suitable for drinking purposes in terms of salinity hazards and arsenic concentration is within the acceptable range. Hence, it can be concluded that groundwater o Mongla city and the surrounding area are good for health.

Keywords: Drinking water; Health status, Water quality, Surrounding, Assessment, and Mongla city.

INTRODUCTION:

Bangladesh is a river-rich country, with several rivers flowing into the Bay of Bengal via the country's landmass. Mongla port area is located 48 km south of Khulna city. Mongla is situated on the confluence of the river Passur and Mongla at Mouza Selabunia, Rampal, Bagerhat. The main rivers are Passur and Mongla (Banglapedia, 2008). The total population of Mongla is 60561; males 57.27%, females 42.73%. The density of the population is 2943 per Km^2. Moreover, the literacy rate among the town's people is 53.6%. Like other rural areas of this district, about 60-70% percent (approx.) of people are living below the poverty line. Most of the people at Mongla engage in agriculture, fishing, day labor, Port labor, shrimp farming, and honey collection from Sundarban. The main crops are paddy, and vegetables and the main export items are paddies, fish (shrimp), and honey. Roads and Rivers are the main means of transportation in Mongla city.

Within Bangladesh, there are several hydrological problems attracts the people of the country. Bangladesh's reservoirs are mostly shallow. Arsenic concentrations have been detected all across Bangladesh, particularly in the central part of the country. The people are suffering from Arsenic poison in the drinking water. Some NGOs and government organizations are working to learn more about the actual source of the contamination and try to increase social awareness to avoid arsenic-contaminated water for human consumption. In Bangladesh, the real reasons for high arsenic levels have yet to be discovered. Hence, the scientist has only relied of two theories. One; the origin of Arsenic is from the underground rocks. When the water in the groundwater table falls then the Arsenic-enriched minerals react with the air and after the groundwater recharge again, Arsenic mixes with the groundwater. Another hypothesis is that Arsenic comes from industrial chemicals and is combined with groundwater. The biggest challenge for aquifers in Bangladesh's southern region is salty water infiltration. The people cannot drink the water because of the high salinity and agriculture production has been hampered because of the high saline water. Some industrial effluent mixing with the groundwater causes the underground water harmful for drinking purposes. Mongla city, in addition to south-west part of Bangladesh's coastline region experiences an acute lack of drinkable water. The fresh-water reservoirs are not suitable at moderate depths, as well as the top water is excessively salty and murky (Win, 2021; Islam *et al*., 2011, 2015). The evaluation of groundwater condition is scarcely used though it is demandable in this coastal region. The harvesting of rainwater could be a potential alternative source of drinking water for similar water-scarce areas (Ahmed *et al*. 2018). Rainwater harvesting and rain-fed pond water have grown as this region's largest prevalent supplier of drinking water. The level of clean drinking water is critical for a community's overall health. Rainwater harvesting as well as rain fed pond water, on the other hand, are more prone to pollution, making it increasingly challenging to provide clean drinking water (Kamruzzaman and Ahmed, 2006; Alam *et al*., 2011; Chidamba & Korsten, 2018).

From the literature review, it has been shown that some research has been done by the national and international authorities regarding harvesting the rainwater for drinking purposes (Islam *et al*., 2019). The climate change and its effects on the resilience community for safe drinking water and health have also been carried out here in the Mongla city (Moniruzzaman *et al*., 2019). According to Mohana *et al*. (2020), the microbial infestation was found in rainwater collected in the Mongla urban areas. Although the contamination at the consumption point reduced after treatment, that did not meet WHO standards in most of the cases. As a result, effective hygiene techniques are required to prevent the quality of gathered rainwater from deteriorating. Higher concentrations of Pb were also found in stored rainwater tanks in some localities in the study area. The As concentration was not found so much though very limited work has been carried out regarding the study of groundwater quality and the assessment of the trace element effects on health. The government and some non-govt. organizations have given more attention to ensure to provide safe drinking water at the community level through the Pipeline, ASR, and desalination plants on a modest scale in this region (Rubel *et al*., 2019; Islam *et al*., 2019).

However, those water supply options are mostly intended to provide potable water to households (Islam *et al*., 2019). Several government and non-govt. organizations emphasize the social context of flood resiliency in the burning research, especially for the northern flood-prone communities in Bangladesh. The groundwater quality and the other sources of water quality are the prime need here in this community. The study report by the CDMP-2 stated that the groundwater in the Khulna Districts is contaminated by Arsenic poison in about 60% of the total tube well. Despite the health risk due to the Arsenic contamination, the detailed status of drinking water and the status of Arsenic concentration in Mongla city are not yet identified before. Hence, we initiated this study to identify the Arsenic concentration in Mongla city. Recently both government and non-govt. organizations take initiatives to find alternative sources of drinking water for the rural coastal population. Some major elements (Fe, Ca, Mg) and the trace elements As, Cd, Pb) dissolved in various sources of drinking water have not been carefully identified so far. The chemical elements and salinity have a greater impact on coast-al agriculture. Hence, research work has been carried out to find the various sources of water for the drinking and status of the Arsenic contamination in the coastal city of Mongla, Khulna, Bangladesh. The specific objectives are to assess the sources of water for drinking purposes. The other objective is to identify the quality of the groundwater and the other sources of water effects on health from the Mongla city, Khulna.

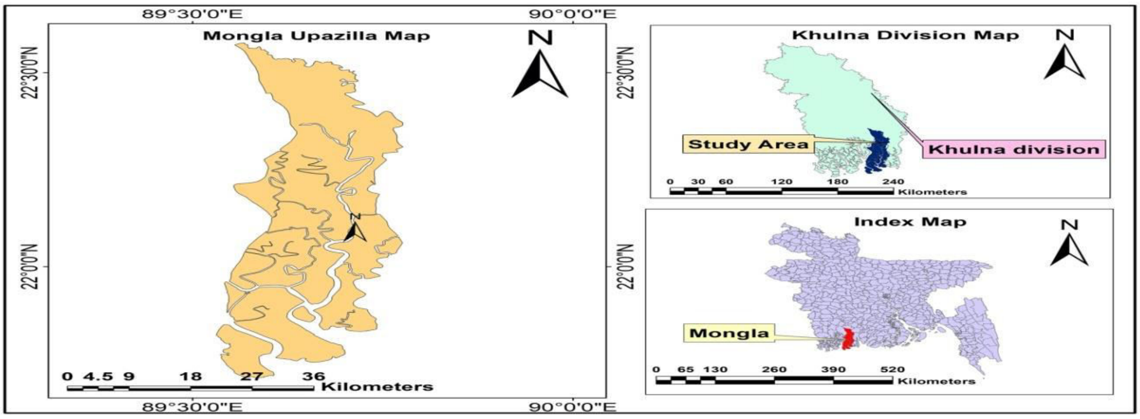

Fig. 1: Location map of Study area (Mongla city).

METHODOLOGY:

The designed study will apply empirical qualitative and quantitative techniques. The overall steps required to complete the research work may be classified as data collection, field sampling, laboratory analysis, data presentation, and interpretation. Secondary data will be gathered from the Bangladesh Bureau of Statistics (BBS), the Local Government Engineering Department (LGED), the Mongla Upazila Office, and the Bangladesh Water Development Board, as well as secondary information at the household level and overall geological subsurface groundwater aquifer information (BWDB). The water sample has been collected from the study area at the household or from the important water sources to examine the further chemical analysis.

The Statistic Package for Social Sciences (SPSS) and EXCEL software, Adobe Illustrator, and Kaleida Graph has been used for primary survey data compilation, analysis, and graphic representation. Various statistical methods of descriptive statistics like frequency, percentage, mean, and standard deviation are used when it comes to general information such as demographic profile, socioeconomic condition. The location maps have been collected from the Google maps and modified by the adobe illustrator software CS 2. As a whole, the stages required to complete the research task can be classed as data collection: Data was gathered from a variety of sources. Samples of water were taken random sampling in the field. It was decided to collect water samples from shallow tube wells and hand tube wells. These were gathered from throughout the city of Mongla.

A total of 24 wells were selected for collecting water samples. Only when a well had been operated on several times were water samples gathered in sterile plastic water bottles (Minimum 15 minutes). Before collecting the samples, the bottles were washed twice with pumping water and then carefully sealed. The arsenic concentration was identified in the field during the sampling by the HA-NNA Arsenic tool kit. All the groundwater samples were further analyzed in the PSTU laboratory to determine the salinity range through the measurement of Electric Conductance (EC) in µs/cm.

RESULTS AND DISCUSSION:

Electrical conductivity (EC)

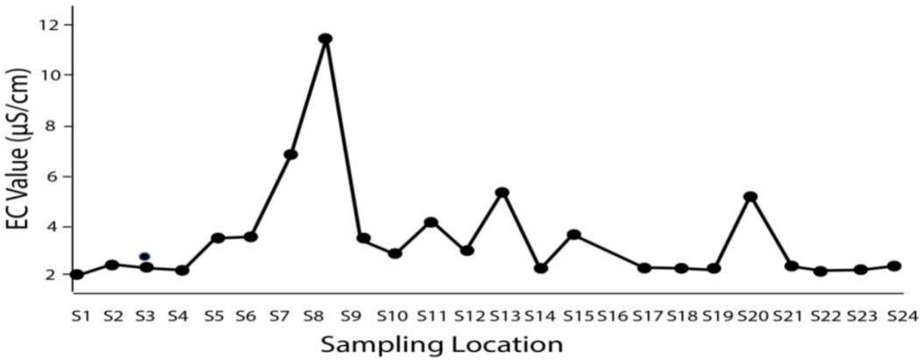

Fig. 2: Electrical conductivity (EC) values from the study area.

Pure water is not a good conductor of electricity, but it is a good insulator. Water conductance is improved by raising its ions concentrations. In general, the quantity of solids dissolved in water determines conductivity. Electrical Conductivity (EC) measures the ionic process of a solution that allows it to conduct electricity. The Level should not surpass 400 µS / cm, by WHO guidelines. According to the existing inquiry, the research area's EC value 4 varies from 0.47 µS/cm to 11.41 µS/cm. As a result, the aquifer in the research region has a decent variety of EC readings (**Table 1**).

Sulphate ($SO4^{2-}$)

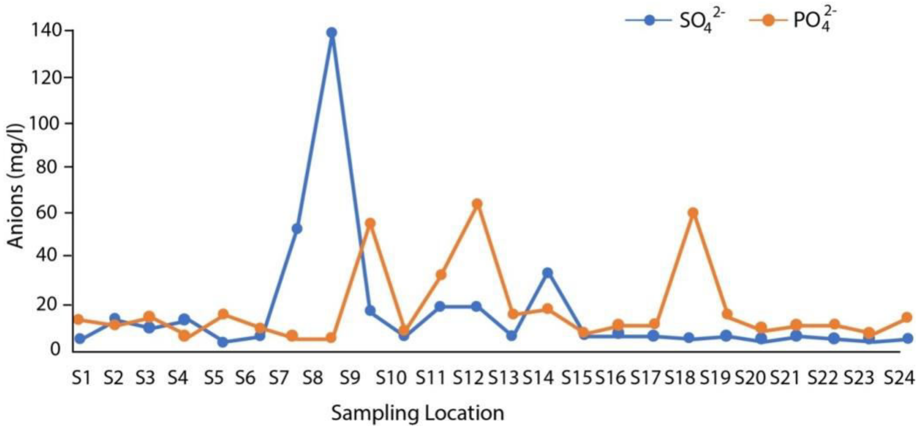

Fig. 3: Hydro-chemical properties of ground water and surface water of the study area.

If there are a lot of sulfates dissolved in the groundwater, it is harmful to your health. The Sulphate concentration ranges from 0.385 mg/l to 136.854 mg/l in Mongla City. The maximum sulfate content in-home drinking water was observed within a 7-kilometer radius of the city, at 136.854 mg/L (**Table 1**). Among 24 samples, 15 samples contain sulfate ions ranging from 0.385mg/l to 2.343 which is aceptable for drinking according to BSTI standards. The other 9 samples' sulfate ion concentration is above 4 mg/l which is not acceptable according to BSTI in Bangladesh (**Fig. 3**).

Phosphate ($PO4^{3-}$)

The concentration of another parameter phosphate found for different water samples from different Tube-wells was variable. Phosphate concentrations in-home water was found to be highest is 61.994mg/l and lowest is 1.756mg/l (**Table 1**). Phosphate in drinking water has a specified value of 1.96 mg/l in Bangladesh. In this study, the obtaining concentration above than standard value was found in 22 samples among 24 samples that are not suitable for drinking (**Fig. 3**).

Potassium (K+)

Potassium is a silvery-white alkali that is highly reactive with water. Potassium is found in all human and animal tissues, especially plant cells, because it is required for the functioning of living organisms. The total amount of potassium in the human body is between 110 and 140 gm/l. It is essential for human

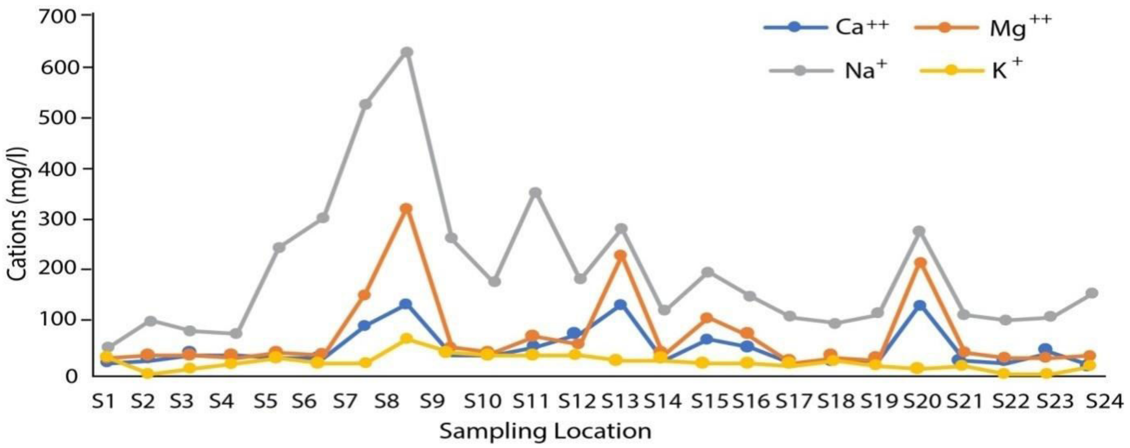

Fig. 4: Hydro-chemical properties of ground water and surface water of the study area.

physical functions such as heart protection, blood pressure regulation, protein disso-lution, muscle con-traction, and nerve stimulation. In rare cases, pota-ssium deficiency can lead to depression, muscle weakness, and cardiac arrhythmias. According to WHO standards, the permissible limit for potassium is 12 mg/l In the study area, potassium content varies between 3.004 mg/l and 71.459 mg/l (**Table 1**). Only 4 Sources among 24 samples are suitable for drin-king purposes (**Fig. 4**).

Sodium (Na+)

Sodium is a silvery-white metal element and is cont-ained in a small amount of water. A sufficient amount of sodium in the human body can prevent many fatal illnesses such as kidney damage, high blood pressure, and headaches. In most countries, the majority water supply is less than 20 mg / l, but in some countries, sodium in water exceeds 250 mg/l (WHO 1984).

Table 1: Hadro-chemical properties of groundwater of the study area.

Sample No.	EC	Ca2+	Mg2+	Na+	K+	SO42-	PO43-
	mg/l	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1c	0.47	23.94	33.434	53.624	33.047	1.548	9.375
2 poura	0.8	27.567	36.953	104.716	3.004	9.782	7.798
3BS	0.67	37.723	36.953	85.066	13.519	5.607	10.387
4P	0.58	36.998	34.314	78.079	23.176	9.682	2.024
5	1.93	31.194	42.232	249.694	31.545	0.661	11.726
6S	1.93	31.194	38.273	305.59	21.03	2.218	5.625
7	5.11	95.759	157.931	529.17	23.391	50.142	1.786
8	11.41	138.561	324.661	631.354	71.459	136.854	1.756
9	1.86	39.174	52.79	263.231	41.845	13.766	52.768
10	1.21	34.822	40.913	182.009	35.837	2.343	4.345
11	2.58	55.134	71.707	358.428	35.408	15.799	29.464
12	1.39	79.074	57.63	185.066	38.197	16.335	61.994
13	3.75	139.286	233.158	285.066	26.395	2.05	12.381
14	0.65	27.567	39.593	119.563	28.755	31.213	15.03
15	2	66.741	109.54	201.659	21.459	2.552	4.226
16	1.27	51.507	75.666	151.004	19.957	2.72	6.964
17	0.67	19.587	23.756	111.266	17.382	2.092	6.815
18	0.65	25.391	32.994	102.533	27.682	1.381	57.411
19	0.64	28.292	28.155	114.76	18.67	2.134	11.101
20	3.59	136.384	219.52	280.262	8.584	0.711	5
21	0.66	24.665	44.432	114.323	17.811	2.301	7.113
22	0.62	21.763	32.554	103.843	2.146	0.745	7.917
23	0.64	43.527	33.434	111.703	1.931	0.385	3.185
24	0.78	14.509	36.953	158.865	18.455	1.715	10.685
Min	0.47	14.509	23.756	53.624	1.931	0.385	1.756
Max	11.41	139.286	324.661	631.354	71.459	136.854	61.994
Ave.	1.91083333	51.2	76.56	203.36	24.19	13.11	14.45

According to WHO standards, the sodium concen-tration in drinking water is 200 mg / l. In the study area, Na + concentrations range from 53.624 mg/l to 631.354 mg/l. The average value is 203.36975/ l. Sodi um levels are generally slightly in the higher range (**Fig. 4**).

Calcium (Ca++)

Calcium is the fifth most abundant element in the crust and is very important for human cell physio-logy and bone. About 95% of the calcium in the human body is stored in bones and teeth. High cal-cium deficiency in humans can cause rickets, poor blood clotting, fractures, and exceeding calcium limits causes cardiovascular disease.

According to WHO standards (2011), the permis-sible range of drinking water is 75 mg/l. Calcium concentrations in Mongla city range from 14.509 mg / l to 139.286 mg / l. In the study area Ca ++ concen-tration exceeds the acceptable limit (**Fig. 4, 5**).

Magnesium (Mg2+)

Magnesium is the eighth most common element in the Earth's crust and is a natural component of water. It is an essential component of the proper functioning of living organisms and is found in minerals such as dolomite and magnetite. The human body contains about 25 g of magnesium (60% in bones, 40% in muscles and tissues). According to WHO standards, the tolerance for magnesium in water should be 50 mg / l. The maximum and minimum magnesium content in the study area is 324.661 mg / l and 23.756 mg / l. The average value is 76.564 mg/l (**Fig. 4, 5**).

Sources of Drinking water:

The inhabitant of the Mongla Upazila uses the water for drinking purposes from different sources especially from tap water. They drink water from the pond after distillations using some local technique. There was no deep tub-well in the Mongla city area and the drinking water is supplied by the commercial organization and so on. In the Rampal area, the people are depends on the tube well water. The study shows the more convenient way and drinking water available throughout the year. The people in the Rampal area get safe drinking water within 50m far away from their house and some are very near to their houses. This makes a safe water supply for the inhabitant of the Rampal area, Khulna.

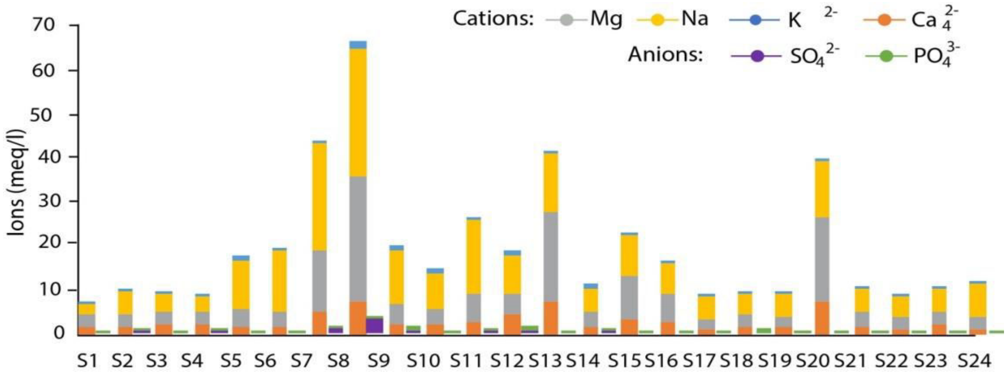

Fig. 5: Hydro-chemical properties of ground water and surface water of the study area.

Availability of Drinking water

The availability of drinking ware in Mongla city depends on the third-party supply of water. People need to purchase a bottle of water for drinking purposes. The poor people have alternative sources of pond water to purify by the *Fitkiri* and other local methods. The tab water is also found in the busy area as the main source of drinking water, especially in the market area. Mongla city is located very near to the coaster hence no deep tube well and found high salinity intrusion unsuitable for drinking purposes. The availability of drinking water in the Rampal area is good enough year-round for safe drinking water. The people of the Rampal area drink water from their tube well which is very convenient to get. Very few people use the tap and pond water for drinking purposes.

Suitability of the Drinking water

The suitability of the drinking water is good for the commercial one as they maintain the ideal composition for the drinking purposes. The suitability of pond water is not much good. It is best for the household purpose but the risk for the drinking purposes. The pH value of drinking water in the study area ranges from 6.7 to 7.38 with an average value of 7.09 which is within the permissible limit for drinking uses.

Arsenic concentration measurement

Humans are primarily exposed to arsenic though the consumption & inhalation. The World Health Organization (WHO) recently revised its original arsenic in drinking water guideline value of 0.05 mg/l. The government of Bangladesh has set a limit of 0.05 mg/l (DOE 1997).Water with a high level of arsenic is lead to health problems such as melanos is, leukomelanos is, hyperkeratosis, black foot disease, cardiovascular disease, hepatomegaly, neuropathy, and cancer (Khan and Ahmed, 1997). Arsenic does not tend to build up in the body and is naturally excreted. If ingested more than it can be excreted, arsenic accumulates in the hair and fingernails (Khan and Ahmed, 1997). The toxic effects of arsenic is determined by its chemical as well as physical aspe-cts, the pathway by which it enters the body, the dose and length of exposure, dietary contents of interacting factors, and the age and sex of those who are exposed. From the analysis it has been observed that all the groundwater samples are in the range between 0 ppb - 335 ppb which is within the range of Bangladesh Arsenic Standard (<50 ppb), according to WHO. There is no Arsenic in the Mongla city and Rampal area. A large number of tube wells were installed by the Government of Bangladesh that had a depth of more than 100 m to obtain Arsenic-safe water in the villages of Rampal. We have systematically collected water samples from 24 tube wells at depth ranges from 229 feet to 365 feet in Mongla and Rampal Upazila of Khulna district, Bangladesh (**Fig. 5**). Arsenic levels of 50 ppb are only always absent in water from hand tube well water deeper than 350m. From the overall investigation, it can be concluded that the Arsenic concentration of Mongla city and Rampal area is within the permissible limit for drinking purposes.

Drinking water quality standard

The drinking water quality standards are those, which all the limitations of water use criteria recommended by the world health organization (WHO, 1983) and the Bangladesh water pollution control Board (BWPCB, 1976) which gives the guideline values of chemical constituents in water for drinking standard. The groundwater of the study area is compared and correlated with whom and Bangladesh's standard for drinking purposes is given in **Table 2**. From **Table 2** it may be concluded that all the parameters that have been determined systematically are suitable for drinking and health purposes, according to (WHO, 1983; BWPCB, 1976; DOE (1997).

Table 2: Correlation of the quality of groundwater o the study area with WHO, DOE and BWPBC for drinking purpose.

Water quality (1983)	WHO standard standard (1976)	DOE Bangladesh standard (1997)	BWPCB study area	Concentration in Parameters
pH	6.5-8.5	6.5-8.5	6.5-9 6.7 to 7.38	- 20-30
TDS (mg/l)	1000	1000	1500	-26-32
Ca^{++} (mg/l)	200	75	-	-154.97 - 1304.65
Mg^{++} (mg/l)	500	30-35	-	- 14.59-139.28
Na^{+} (mg/l)	200	200	-	- 23.75-324.66
K^{+} (mg/l)	-	12	-	- 53.62-631.35
SO_4^{--}(mg/l)	400	400	400	- 1.9-71.45
PO_4^{---}(mg/l)	-	-	-	- 0.38-136.85

CONCLUSION:

This study examines the overall risk of Arsenic and salinity in and around the drinking water in the city of Mongla. Water samples were taken from 24 different wells. The average temperature of the drinking water samples collected from the study area is 27°C and the temperature range is 26 to 29 °C. The pH of drinking water is in the operating range of 6.7 to 7.38, with an average of 7.09 in the safe range for drinking. The EC value of drinking water in the study area varies between 0.47 and 11.41 µS/cm, with an average of 1.91 µS/cm, which is part of the water quality condition. TDS concentrations range from 95.96 to 1365.60 mg/l. This means that all results are within acceptable consumption limits. Analysis showed that all groundwater samples ranged from 0 ppb to 335 ppb, which is in the range of the Bangladesh arsenic standard (<50 ppb). All para-meters are systematically determined based on the purposes related to health. As measured by Salinity hazards, the groundwater in the study area is light to moderate, and potable, and the concentration of Arsenic is within acceptable limits. Consequently, it can be concluded that groundwater is beneficial to human health.

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CONFLICTS OF INTEREST:

This paper has not been submitted to, nor is it under review at, another journal or other publication site.

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