**Original Article**

# Effects of Salinity on Menstrual and Reproductive Health: Insights from Coastal and Non-Coastal Areas of Bangladesh.

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## Abstract

**Background:** Salinity intrusion in coastal regions of Bangladesh is a growing concern due to its potential impact on public health, particularly reproductive health among women. Exposure to saline water may contribute to a variety of health challenges, including menstrual irregularities and pregnancy complications.

**Objective:** This study aimed to assess the reproductive health challenges faced by women in salinity-affected areas and compare these findings with women living in non-salinity-affected areas in Bangladesh.

**Methods:** A cross-sectional comparative study was conducted among 647 married women of reproductive age (15–49 years), with 405 participants from salinity-affected areas and 242 from non-salinity-affected areas. Data were collected using a pretested structured questionnaire and face-to-face interviews. Water samples from the study areas were tested for salinity and other parameters, including pH, electrical conductivity (EC), total dissolved solids (TDS), and sodium (Na). Statistical analyses included chi-square tests, ordinal logistic regression, and the Mann-Whitney U test, with a significance level set at $p < 0.05$.

**Results:** Women in salinity-affected areas exhibited significantly higher rates of reproductive health issues, including irregular menstrual cycles (42.5% vs. 27.3%, $p < 0.01$), genital itching (38.2% vs. 18.6%, $p < 0.001$), and lower abdominal pain (35.4% vs. 20.2%, $p < 0.001$). Pregnancy complications were more prevalent in salinity-affected areas (48.6% vs. 32.4%, $p < 0.01$). Water quality analysis revealed higher salinity (4.5±1.3 ppt vs. 0.6±0.2 ppt, $p < 0.001$) and elevated sodium levels in the affected areas.

**Conclusion:** Salinity-affected areas in Bangladesh show a higher burden of reproductive health challenges among women, which may be linked to poor water quality. Effective interventions, including water treatment and community health education, are essential to mitigate these health risks.

**Keywords:** Salinity intrusion, reproductive health, water quality, menstrual health, pregnancy complications.

## Introduction

Saline intrusion is also a typical feature environmental challenge in Bangladesh, and most areas along its coast are worst hit. Various natural and artificial factors worsen the water salinity, limiting the availability of fresh water, agricultural activities, human health, and the general means of survival[1]. Such effects are felt as a result of the unique geographic and climate features of the country, the rise in the level of waters in the sea, and unsustainable practices. However, environmental conservation is a challenge that requires a global approach. It is a problem of extreme urgency requiring collaborative will action and shared responsibility[2]. Recently, the salinity issue has been intensively studied, and several working factors have been identified, which helps understand the causes[3]. The proximity of coastal aquifers to the Bay of Bengal results in salinity intrusion that affects Bangladesh. Higher sea levels, a product of global climate change, permit seawater to reach farther inland during the dry season when river flows are subsided[4]. The rise in groundwater consumption for farming and daily needs, particularly in urban areas, worsens the situation by lowering the freshwater table, which increases its susceptibility to salinity water invasion. Salinity intrusion is also exacerbated by human activities, such as the practices involved in shrimp aquaculture along the coast, which reconfigure the natural equilibria of fresh and saltwater bodies[5]. Climate change has negatively impacted rainfall patterns, and dry season rainfall and freshwater river discharges, which are supposed to protect areas from saline water, are now minimal. These combined factors have led to an increased rate of salinity progression in Bangladesh[6]. SRDI (Soil Resources Development Institute) in Bangladesh has revealed a 132% increase in saline areas from 1973 to 2009. Increased climatic variability and rapidly growing population have contributed to the increasing vulnerability of southeastern and southwestern parts of Bangladesh including Khulna, Satkhira, Bagerhat, Patuakhali, Noakhali, Cox's Bazar, and Chattogram[7]. So, future migratory potential due to salinity intrusion is alarmingly disastrous by any estimates as about 35 million people living in coastal Bangladesh vulnerable to salinity are expected to increase due to the factors of sea level rise due to climate change, population growth, and urbanization[8]. Saline water is a significant menace for inland farmers and the agriculture sector because most of the population resides in rural areas and depends on agriculture, which is critical to food security. Agricultural productivity is severely compromised by salinity intrusion, as salinity affects soil fertility and the overall health of crops[9]. Farmers growing rice, a traditional crop that requires much freshwater, are forced to adopt other less profitable crops. Salinity-tolerant crops also benefit aquaculture activities, decreasing biodiversity as salted-tolerant ones replace many freshwater species[10]. This means that water salinity is a direct and indirect threat to human beings. Studies have shown an association between consuming saline water and an increased risk of hypertension, chiefly among pregnant women. Diarrhea, cholera, and skin infections are also partly caused by salinity during the dry season when freshwater resources are scarce. Salinity in these regions has also resulted in infant mortality and stunted growth[11,12]. Insecurity of socioeconomic status is another reason for understanding the consequences of saltwater intrusion. Water scarcity compels people to use expensive sources such as bottled water or travel long hours to fetch water, which is costly and involves time wastage. Saline water also leads to structural deterioration of infrastructure such as roads and houses. Such challenges worsen poverty and stifle coastal areas' development. Thus, many of the vulnerable groups end up suffering from a cycle of poverty[12,13]. Bangladesh is one among many low-lying deltaic countries located close to sea level and most impacted by the effects of climate displacement in its coastal regions. Of the wide range of phenomena associated with climate change, the intrusion of salinity into the coastal zone of Bangladesh is one of the widespread reversible phenomena and one with serious implications[1]. The increasing salinity levels in the soil and water bodies not only hamper agriculture and livelihoods but also grow as a threat to general health and reproductive health in particular[12,14]. This study explores fertility problems associated with the salinity concentration of Bangladesh's coastal region and is limited to two unions of Koyra Upazila, Uttar Bedkashi and Dakhin Bedkashi from Khulna district, which were used for comparative analysis.

As intertwined as these problems are in social contexts, there are glaring health issues regarding the coastal women's menstruation cycle, including mental health stress, hygiene, and effective management of the menstruation cycle[16]. For instance, Roy et al. (2021) and Alston (2015) noted that when there is a shortage of food supply in the family, women often bear the brunt of the shortage compared to males[15,16]. Women of coastal regions experience difficulties relating to their menstrual hygiene and management even during basic lavatorial activities owing to the use of salty water for those activities[18]. Saltwater irritates their sensitive parts, causing vaginal and urinary tract infections, as well as discomfort during menstrual flow[19]. Similarly, excessive saline water intake leads to severe challenges in a woman's reproductive health[17,19]. 66% of salinity-afflicted coastal women and girls suffer from abdominal pelvic inflammatory diseases[17]. Hypertensive disorders in pregnancy are a significant cause of maternal and perinatal death, especially in low-income countries[20]. Among these, (pre)eclampsia ranks among the five leading direct causes of maternal deaths[20,21] and is also responsible for perinatal death through elevated risk of preterm birth and intrauterine growth restriction, high childhood blood pressure (BP) in children born of affected mothers, and increased maternal future cardiovascular disease[22,23]. Epidemiological solid evidence links high salt intake with the risk of hypertension in both children and adults[24]. Nevertheless, the influence of salt on the development of hypertensive disorders in pregnancy is still poorly understood, as noted in a Cochrane review [25]. The prevalence of (pre)eclampsia and gestational hypertension on Bangladesh's coast was also found to be higher than in the country's non-coastal areas, based on a 2008 survey[26]. The rates were also remarkably high in the dry season when salinity concentrations in surface and groundwater are more elevated than in the monsoon season[27,28]. That's because Bangladesh's roughly 40 million coastal population depends on natural water sources such as ponds, rivers, and tube wells for drinking water supply. These sources have already been highly salinized due to seawater intrusion due to climate change and anthropogenic factors such as water management and shrimp aquaculture[29]. Salinity has already spread >100 km inland from the Bay of Bengal, and the impacts are projected to be worsened by sea level rise due to climate change and excessive groundwater withdrawals from aquifers[30,31]. Females in given regions primarily consume water with high salinity due to the unavailability of fresh water, and thus, high sodium consumption is observed[32]. This chronic exposure harms the body by altering average fluid balance since excessive sodium in the system leads to dehydration. Dehydration leads to an increased concentration of urine, which increases bacterial growth in the individual's urinary system[33]. Further, low water intake decreases the rate of urination, thus weakening the body's ability to wash out the urinary tract and raising the likelihood of UTIs[34]. The high salt content puts pressure on the kidneys to filter large amounts of sodium out of the body. This stress can increase the propensity to develop renal stones since the increased concentration of urine accelerates the process of crystal clumping[35]. Kidney stones act as a barrier to the free passage of urine and encourage bacterial growth in the urinary tract, raising the potential of UTI. Like the above, saline water may also progressively reduce renal function over time and increase the risk of recurrent UTIs in women living in these areas[36,37,38].

## Materials and methods

The research focused on analyzing reproductive health problems among women living in salinity-affected and unaffected areas of southwest Bangladesh. Our study sought to determine the impact of water salinity combined with demographic and health-related aspects on women's reproductive health. Our research utilized mixed-methods research to combine quantitative and qualitative data collection techniques across multiple study sites.

### Design and Population

The cross-sectional comparative study carried out from July 2022 to July 2024 evaluated reproductive health challenges experienced by women living in saline and non-saline areas. The research included a total of 647 married women in the age range 15-49 years among whom 405 lived in salinity-affected regions and 242 resided in non-salinity regions. The researchers chose participants by considering their marital status and age as reproductive-aged adults who lived in either saline or non-saline regions within Khulna and Jashore districts.

### Place of Study

The study took place across salinity-affected and non-salinity-affected regions within Bangladesh. Koyra Upazila's Uttar Bedkashi and Dakhin Bedkashi Unions in Khulna District and Shamnagar Upazila's

Gabura and Burigoaloni Unions in Satkhira District were among the salinity-affected areas. The regions unaffected by salinity concerns included Arabpur and Chanchra Unions of Jashore Sadar Upazila in Jashore District together with Fultola, Damodar, Jamira, and Atra Unions of Fultola Upazila in Khulna District.

**Data Collection Methods and Tools**

Data collection utilized a pretested structured questionnaire to obtain information on socio-demographic variables and reproductive health factors. Face-to-face interviews with participants were conducted by trained enumerators who obtained informed consent from each participant before collecting data.

**Variables included in the study**

• Socio-demographic characteristics: Age, marital status, education level, occupation, type of residence, sanitation facilities, and economic status

• Water sources and quality:

Collect information about water sources for drinking, bathing, and cooking, including tubewells, ponds, and tap water.

• Reproductive health indicators: Age at menarche. Regularity of the menstrual cycle, itching in genitalia, vaginal discharge, lower abdominal pain, History of pregnancy complications, and number of children

• Health conditions: Symptoms include diarrhea, vomiting, fever, the common cold, skin and eye infections, and high blood pressure.

**Water quality testing**

Water samples were collected from the following sources.

• Areas affected by salinity: Fifteen tube wells and six ponds water samples from Uttor and Dakhin Bedkashi unions of Koira Upazila, Khulna District.

• Salinity-Free Zone: Four tap water and six tube well water samples were taken from Arabpur and Chachra unions in Jashore Sadar Upazila of Jashore District.

**Water collection procedure**

Water samples were obtained from selected tube wells and taps with a lot of caution. For tube wells, the well was pumped for 5 minutes repeatedly before the water was gathered. New plastic bottles were unwashed to omit any contamination and filled to the brim before caps were placed carefully to form a seal. The bottles had no air bubbles trapped inside them which guarantees no oxidation of reduced substances during transfer and storage. Similar procedures were followed for tap water, where it was collected directly from kitchen taps. All samples were kept in sealed icebox after collection. After attending the laboratory, water samples were subjected to chemical analyses without delay to reduce any chemical or biological changes that would take place.

**The following parameters of water are tested in the laboratory**

1. pH
2. Electrical conductivity (EC)
3. Salinity
4. Total dissolved solids (TDS)
5. Sodium (Na)
6. Calcium (Ca)
7. Magnesium (mg.)
8. Iron (Fe)
9. Dissolved oxygen (DO).

Water samples are analyzed using standardized laboratory procedures and equipment to ensure accuracy and reliability

**Statistical analysis plan**

Descriptive statistics of the study were compared between participants from salinity and non-salinity areas. Differences in menstrual and reproductive health complications between the two areas were assessed using the chi-square test for 2x2 contingency tables, while the chi-square test with Yates' continuity correction was applied for tables larger than 2x2 to estimate p-values. To evaluate the risk of menstrual and reproductive health complications among participants from salinity areas compared to those from non-salinity areas, ordinal logistic regression was used for binary outcomes, and multinomial logistic regression was applied for ordinal outcomes.

Water samples were collected from common water sources in both areas to measure pH, salinity, electrical conductivity (EC), and total dissolved solids (TDS). The Mann-Whitney U test was performed to determine differences in water quality parameters between the two areas. A p-value $<0.05$ was considered statistically significant. Statistical analyses were conducted using STATA (version 15), and graphical presentations were created with GraphPad Prism 8.3.2.

**Ethical considerations**

The study followed ethical guidelines for participant research. Informed consent was obtained from all participants, whose responses were kept confidential and anonymous. Ethical approval for this study was obtained from the Research and Innovation Centre of Khulna University with the reference number: KUECC-2025-01-01

## Results

Table 1 describes the demographic characteristics of study participants from salinity (n=405) and non-salinity (n=242) areas. The mean age of both groups was similar (mean±SD) (30.9±9.15 years vs. 30.4±8.47 years). The rate of no formal education was higher in the salinity area (21.7% vs. 12.8%), whereas more participants from the non-salinity area completed secondary or higher education. While checking the occupational status, more homemakers in the non-salinity area (44.6% vs. 39.8%) and the presence of day laborers and fish farm workers in the salinity area. Housing conditions differed, with 46.9% of salinity-area participants living in mud houses compared to 63.6% in the non-salinity area. Most participants used water-sealed pit latrines, though this was more common in the non-salinity area (76.0% vs. 66.2%). Socioeconomic status varied, with a higher proportion of middle-class participants in the non-salinity area (45.9% vs. 32.8%). Tubewells were the primary drinking water source in both areas, though reverse osmosis plants were used only in the salinity area. All participants in the salinity area used pond water for bathing, while some in the non-salinity area used tubewells (18.6%). The age of menarche was generally earlier in the salinity area, with a higher proportion experiencing it by age 9 (46.9% vs. 29.3%).

**Table 1. Demographic characteristics of the study participants**

| Observations | Salinity area (n=405) | Non-salinity area (n=242) |
|---|---|---|
| Age, years | 30.9±9.15 | 30.4±8.47 |
| Education | | |
| No formal education | 88(21.7%) | 31(12.8%) |
| Primary | 107(26.4%) | 44(18.2%) |
| Secondary | 86(21.2%) | 74(30.6%) |
| SSC | 56(13.8%) | 45(186%) |
| HSC | 38(9.38%) | 23(9.50%) |
| Graduate | 30(7.41%) | 25(10.3%) |
| Occupation | | |
| Homemaker | 161(39.8%) | 108(44.6%) |
| Student | 0 | 22(9.09%) |
| Livestock business | 62(15.3%) | 84(34.7%) |
| Laborer at a fish farm | 70(17.3%) | 28(11.6%) |
| Day laborer | 68(16.8%) | 0 |
| Teacher | 27(6.67%) | 0 |

| | | |
|---|---|---|
| FWA | 17(4.20%) | 0 |
| Housing status | | |
| Mudhouse | 190(46.9%) | 154(63.6%) |
| Tin shed | 125(30.9%) | 88(36.4%) |
| Building | 90(22.2%) | 0 |
| Sanitation | | |
| Pit latrine with no water | 137(33.8%) | 58(24.0%) |
| Water-sealed pit latrine | 268(66.2%) | 184(76.0%) |
| Socioeconomic status | | |
| Upper middle class | 30(7.41%) | 22(9.09%) |
| Middle class | 133(32.8%) | 111(45.9%) |
| Lower middle class | 177(43.7%) | 86(35.5%) |
| Lower class | 65(16.1%) | 23(9.50%) |
| Source of drinking water | | |
| Tubewell | 347(85.7%) | 242(100.0%) |
| Reverse osmosis plant | 58(14.3%) | 0 |
| Source of bathing water | | |
| Tubewell | 0 | 45(18.6%) |
| Pond | 405(100.0%) | 197(81.4%) |
| Source of the cooking water | 405(100.0%) | 242(100.0%) |
| Age of menarche | | |
| 8 years | 81(20.0%) | 32(13.2%) |
| 9 years | 190(46.9%) | 71(29.3%) |
| 10 years | 73(18.0%) | 54(22.3%) |
| 11 years | 61(15.1%) | 85(35.1%) |

Data was presented as mean with standard deviation for continuous observation and number with percent in the parenthesis for qualitative observations.

Menstrual irregularity was significantly more common in the salinity area (58.5% vs. 15.3%, $p<0.001$), and the risk of irregular menstruation was 10.6 times higher among salinity area's participants compared to the non-salinity area (Table 2 and Figure 1 and supplementary table 1). Vaginal discharge was heavier in the salinity area, with 43.7% experiencing heavy discharge compared to 19.0% in the non-salinity area ($p<0.001$) which is 11.5 times (95% CI=6.57, 20.3; $p<0.001$) and 5.35 times (95% CI=3.14, 9.10;

p<0.001) higher among salinity areas. Vaginal itching or discomfort occurred very often among 41.0% of salinity-area participants, compared to 14.1% in the non-salinity area (p<0.001), after employing multinomial logistic regression it was 6.47 times higher among the salinity area's. Lower abdominal pain and discomfort were also more frequent in the salinity area, with 42.7% reporting it very often compared to 12.8% in the non-salinity area (p<0.001), and the significant risk of it was noted at 4.41, 2.15- and 9.47-times higher risk for sometimes, often and very often vaginal itching or discomfort respectively, compared to non-salinity area's participants. Pain during micturition was more severe and frequent among salinity-area participants (47.3% vs. 33.9%, p<0.001) which is 2.71 times higher (95% CI 1.59, 4.61) (Table 2 and Figure 1 and supplementary table 1).

**Table 2. Distribution of menstrual and reproductive health complications between salinity and non-salinity areas.**

| Menstrual cycle history | Salinity area (n=405) | Non-salinity area (n=242) | p-value |
|---|---|---|---|
| Regular | 168(41.5%) | 205(84.7%) | <0.001 |
| Irregular | 237(58.5%) | 37(15.3%) | |
| Vaginal discharge | | | |
| Light | 89(22.0%) | 127(52.5%) | <0.001 |
| Moderate | 139(34.3%) | 69(28.5%) | |
| Heavy | 177(43.7%) | 46(19.0%) | |
| Vaginal itching/discomfort | | | |
| Rarely | 80(19.8%) | 106(43.8%) | <0.001 |
| Sometimes | 86(21.2%) | 46(19.0%) | |
| Often | 73(18.0%) | 56(23.1%) | |
| Very often | 166(41.0%) | 34(14.1%) | |
| Lower abdominal pain/ discomfort | | | |
| Rarely | 75(18.5%) | 126(52.1%) | <0.001 |
| Sometimes | 102(25.2%) | 40(16.5%) | |
| Often | 55(13.6%) | 45(18.6%) | |
| Very often | 173(42.7%) | 31(12.8%) | |
| Pain during micturition | | | |
| Rarely | 75(18.6%) | 76(31.4%) | <0.001 |
| Sometimes | 83(20.5%) | 48(19.8%) | |
| Often | 55(13.6%) | 36(14.9%) | |

| | | | |
|---|---|---|---|
| Very often | 191(47.3%) | 82(33.9%) | |
| History of pregnancy | | | |
| Yes | 315(77.8%) | 188(77.7%) | 0.978 |
| Pregnancy complication | 105(25.9%) | 52(21.5%) | |
| Number of children | | | |
| No child | 96(23.7%) | 54(22.3%) | 0.522 |
| 1 child | 101(24.9%) | 61(25.2%) | |
| 2 children | 166(41.0%) | 105(43.4%) | |
| 3 children | 42(10.4%) | 22(9.09%) | |
| Types of complications | | | |
| Abortion | 18(4.44%) | 6(2.48%) | <0.001 |
| Eclampsia | 18(4.44%) | 6(2.48%) | |
| Pre-eclampsia | 13(4.69%) | 9(3.72%) | |
| Anemia | 28(6.91%) | 14(5.79%) | |
| Prom | 19(4.69%) | 17(17.0%) | |
| Normal or never pregnant | 303(74.8%) | 190(78.5%) | |

Data was presented as mean with standard deviation for continuous observation and number with percent in the parenthesis for qualitative observations. The Chi-square test was used for 2X2 contingency tables and the Chi-square test with Yates' continuity correction was applied for more than 2X2 contingency tables to estimate the p-value.

Regarding reproductive history, pregnancy rates were similar between the two areas (77.8% vs. 77.7%), though pregnancy complications were slightly more common in the salinity area (OR=2.29, 95% CI=1.15, 2.74; p>0.001) (25.9% vs. 21.5%). The number of children per participant did not differ significantly. However, complications such as abortion, eclampsia, pre-eclampsia, anemia, and premature rupture of membranes (PROM) were reported more frequently in the salinity area, with abortion and eclampsia rates being nearly double compared to the non-salinity area (p<0.001). The probability of abortion was significantly (p=0.020) higher by 4.32 times higher among salinity area's compared to non-salinity area's participants. These findings highlight a higher burden of menstrual and reproductive health complications among participants from salinity-affected areas.

**Supplementary Table 1.** The risk of Salinity in Menstrual and Reproductive Health compared to non-salinity area's participants.

| Menstrual cycle history | OR (95% CI) | p-value |
|---|---|---|
| Regular | 1 (Ref.) | |
| Irregular | 10.6(6.44, 17.3) | <0.001 |
| Vaginal discharge | | |
| Light | 1 (Ref.) | |
| Moderate | 5.35(3.14, 9.10) | <0.001 |
| Heavy | 11.5(6.57, 20.3) | <0.001 |
| Vaginal itching/discomfort | | |
| Rarely | 1 (ref) | |
| Sometimes | 2.37(1.32, 4.23) | 0.004 |
| Often | 1.39(0.80, 2.44) | 0.244 |
| Very often | 6.47(3.68, 11.4) | <0.001 |
| Lower abdominal pain/ discomfort | | |
| Rarely | 1(ref) | |
| Sometimes | 4.41(2.49, 7.81) | <0.001 |
| Often | 2.15(1.15, 4.00) | 0.016 |
| Very often | 9.47(5.34, 16.8) | <0.001 |
| Pain during micturition | | |
| Rarely | 1(ref) | |
| Sometimes | 1.94(1.05, 3.58) | 0.033 |
| Often | 1.56(0.82, 3.07) | 0.171 |
| Very often | 2.71(1.59, 4.61) | <0.001 |
| Pregnancy complication | 2.29(1.15, 2.74) | 0.011 |
| Types of complications | | |
| Abortion | 4.32(1.26, 14.8) | 0.020 |
| Eclampsia | 1.23(0.41, 3.71) | 0.710 |
| Pre-eclampsia | 1.41(0.54, 3.71) | 0.487 |
| Anemia | 1.31(0.56, 3.05) | 0.532 |
| Prom | 0.60(0.26, 1.37) | 0.226 |
| Normal or never pregnant | 1 (Ref) | |

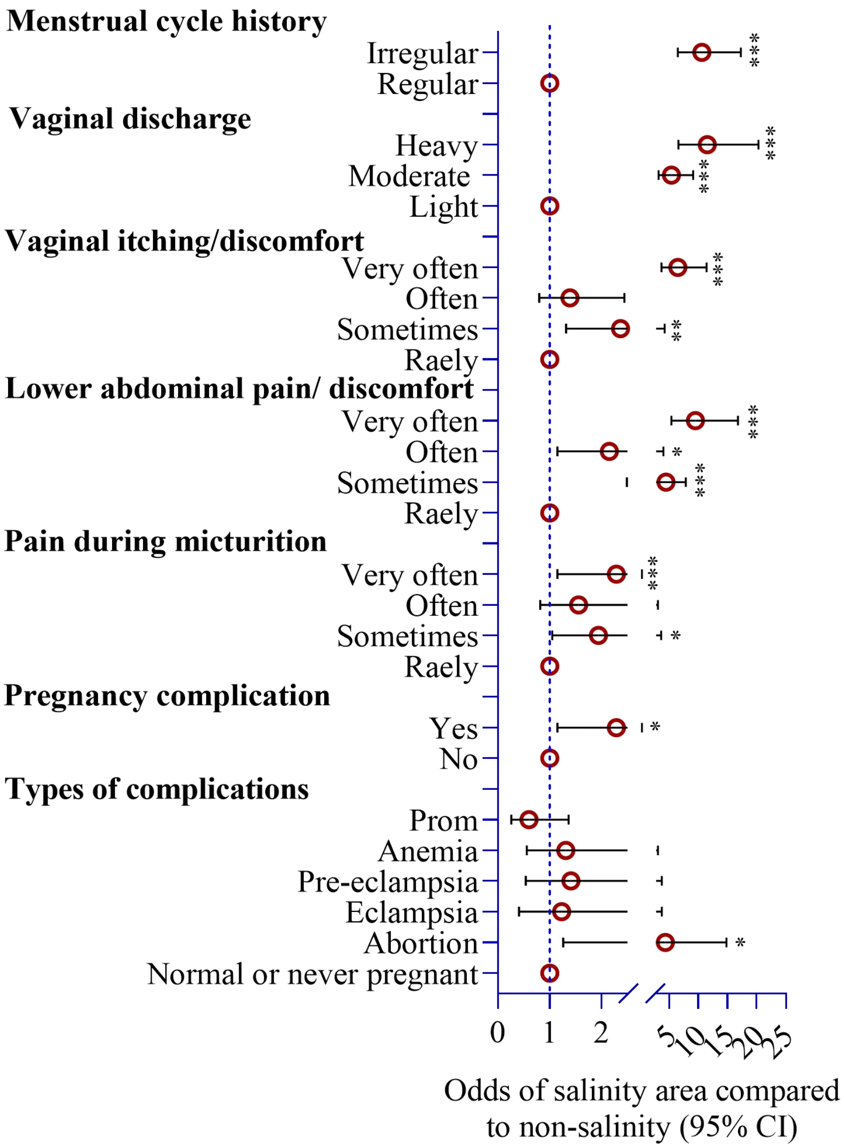


Figure 1. The risk of Salinity on Menstrual and Reproductive Health compared to non-salinity area's participants. To estimate the odds ratio and p-value we used ordinal logistic regression for binary observations and multinomial logistic regression for ordinal observations.

The mean pH level was significantly lower ($p<0.001$) in the source water of salinity area (6.99±0.14) compared to non-salinity area (7.55±0.14) (Figure 2)

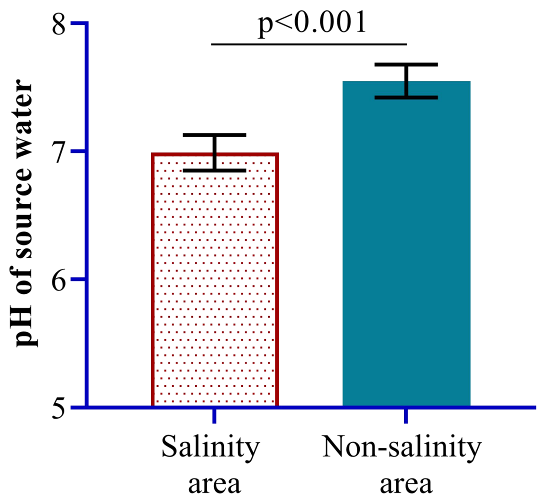


**Figure 2.** Difference in pH levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.

Average concentration of salinity showed significantly higher ($p<0.001$) in the source water of salinity area (2.19±0.72) compared to non-salinity area (0.05±0.01) (Figure 3).

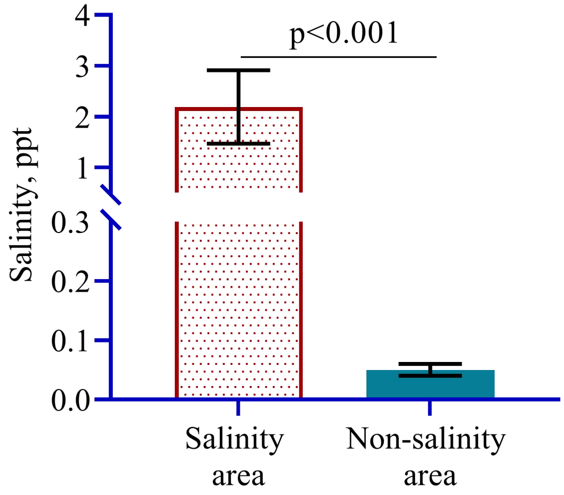


**Figure 3.** Difference in salinity levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.

Similar to concentration of salinity the electrical conductivity (EC) also showed significantly higher ($p<0.001$) in the source water of salinity area (3415.0±1124.0) compared to non-salinity area (203.0±17.0) (Figure 4).

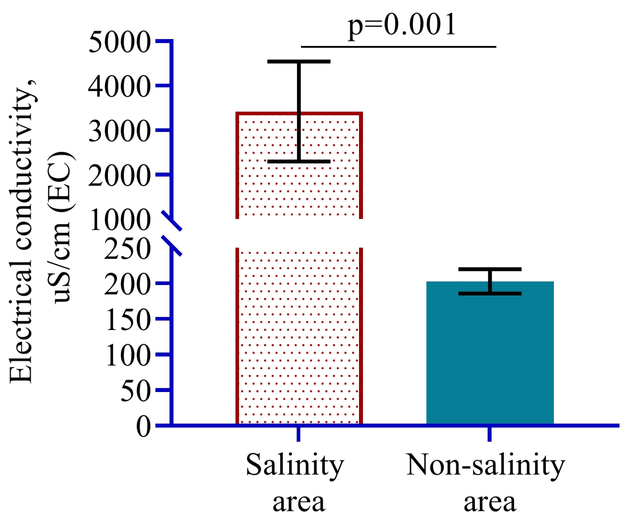


**Figure 4.** Difference in electrical conductivity (EC) levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.

Total dissolved solids (TDS) also revealed significantly ($p<0.001$) higher concentrations of the source water of the salinity area (2185.0±719.5) compared to non-salinity area (129.3±10.7) (Figure 5)

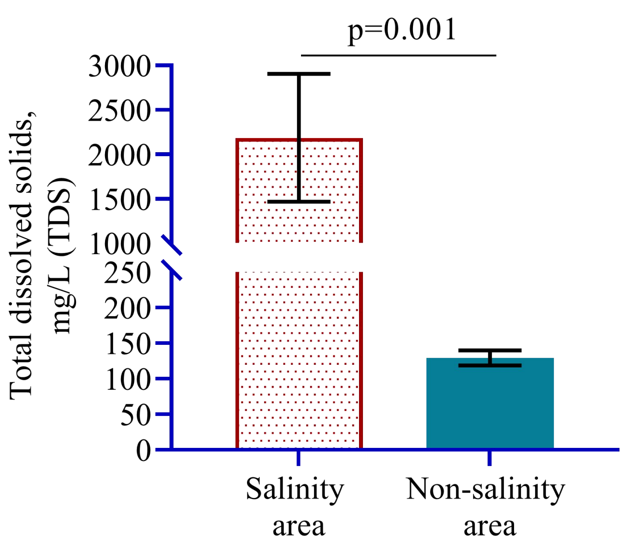

**Figure 5.** The difference in total dissolved solids (TDS) levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.

**Discussion**

The study confirms that salinity has adverse impacts on the menstrual and reproductive health of women who reside on the coast of Bangladesh. The variation between regions with salinity and areas with none of it shows that it is high time to introduce effective measures to address this issue[38,39]. Women in zones of high-water salinity have more complications during pregnancy such as miscarriages, eclampsia, pre-eclampsia, anemia, and premature rupture of the membranes. This postulates a positive relationship between exposure to salinity and poor reproductive outcomes[40].

**Several biological mechanisms may underlie this relationship:**

- ✓ Endocrine Disruption: Sodium and chloride ions, salt ingredients, destroy the natural hormonal balance that controls menstrual cycles and reproduction. This disruption may cause the woman to miss some periods, have an abortion, and have other problems with fertility[41,42].
- ✓ Oxidative Stress: The application of salinity leads to oxidative stress and, therefore, impacts cells and tissues[43,44]. Reproductive health; oxidative stress creates poor-quality eggs and sperm and women have low chances of getting pregnant or getting complicated pregnancies[45,46].
- ✓ Inflammation: Chronic exposure to salinity leads to inflammation in the body[47]. Inflammation processes can act on the reproductive organs and cause PID and endometriosis[48].
- ✓ Nutritional Deficiencies: Since salt can increase the degree of binding between the soil and water molecules, the needed nutrients for crops and consequently for the diet are limited[49,50]. Several nutrients may also affect the female reproductive cycle, especially iron deficiency and folic acid[51,52].

While inflammation is known to be detrimental to health in acutely exposed populations, the direct link between salinity and diseases such as PID, or endometriosis in humans is still unknown. However, since there are inflammatory processes at the base of this connection, it is logical; that more research may help to clarify this link.

**Health Disparity and Socioeconomic Clauses:**

Women in salinity-affected areas are generally of low socioeconomic status, which may also act synergistically to potentiate the adverse effects of salinity on menstrual and reproductive health[27]. Access to quality health care, sanitation facilities, and nutrition are often inadequate, which can weaken women's reproductive health. Poor reproductive health outcomes might also be attributed to cultural and social issues such as early marriage and limited educational attainment [27,53,54].

**The importance of water quality and its impact:**

The levels of pH, salinity, and total dissolved solids coupled with the electrical conductivity of water sources in the salinity-affected areas are much higher than in the other areas hence they are serious health hazards[55-58]. There are many diseases that come with contact with water, including urinary system infections and affect reproduction. Also, water quality can be awful, affecting good hygiene practices, and raising chances of getting reproductive tract infections[59,60].

**Directions for Further Studies**

Managing the health problems caused by salinity requires a combination of measures.

Key policy interventions include:

• **Improved water quality:** Ensuring availability of adequate funds for water treatment and sanitation to reduce the quantity and quality of water that people are exposed to.

• **Public Health Education:** The use of health education programs to create awareness of the health hazards that are associated with exposure to high levels of salinity and the right measures that should be taken to prevent the adverse effects.

• **Nutrition Interventions:** Ensuring that the clients get proper foods and vitamin supplements to feed the nutrient gaps and enhance the health of the clients.

• **Strengthening Healthcare Systems:** Enhancing healthcare service delivery, especially maternal health services and access to family planning commodities, especially to the rural and underprivileged populations.

• **Climate Change Adaptation:** Designing adaptation measures for climate change with the view of reducing the effects of salinity and other climate change stressors.

Further research should be done in the areas of chronic effects of salinity on human health and its effects on future generations. Also, research on the impact of interventions to enhance reproductive health in areas of salinity is also lacking. Through understanding the root of the issues associated with salinity health issues, policy maker, health officials, and researchers can all come together to enhance the reproductive health of the women in the coastal areas of Bangladesh and other similar areas.

**Limitations of the Study**

However, this study has its limitations, which should be considered to appreciate the findings regarding the effects of salinity on menstrual and reproductive health. The cross-sectional design restricts the making of causal conclusions. Further, the use of survey data can be problematic due to the issues of common method variance. Longitudinal research designs with more accurate assessment of exposure and health effects are required to elaborate on the findings in the future.

## Conclusion

Therefore, the results of the present study call for immediate intervention to minimize the effects of salinity on the menstrual and reproductive health of women in coastal areas of Bangladesh. It is therefore possible to increase the health and well-being of affected populations, through the provision of effective comprehensive interventions that address both the acute and chronic effects of exposure to salinity.

## Conflict of interest

The authors declare that there is no conflict of interest.

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## Author Contributions

- **Farhana Ferdaus (PhD Student, Environmental Science Discipline, Khulna University, Bangladesh)**: Corresponding Author, First Author

  Conceptualized and designed the study, collected and analyzed the data, and wrote the manuscript. Led the research process and interpreted the findings.

- **Prof. Dr. Salma Begum (Professor, Environmental Science Discipline, Khulna University, Bangladesh)**:

  Supervised the study, provided valuable guidance and feedback on the research methodology, and reviewed the manuscript for critical insights and academic rigor.

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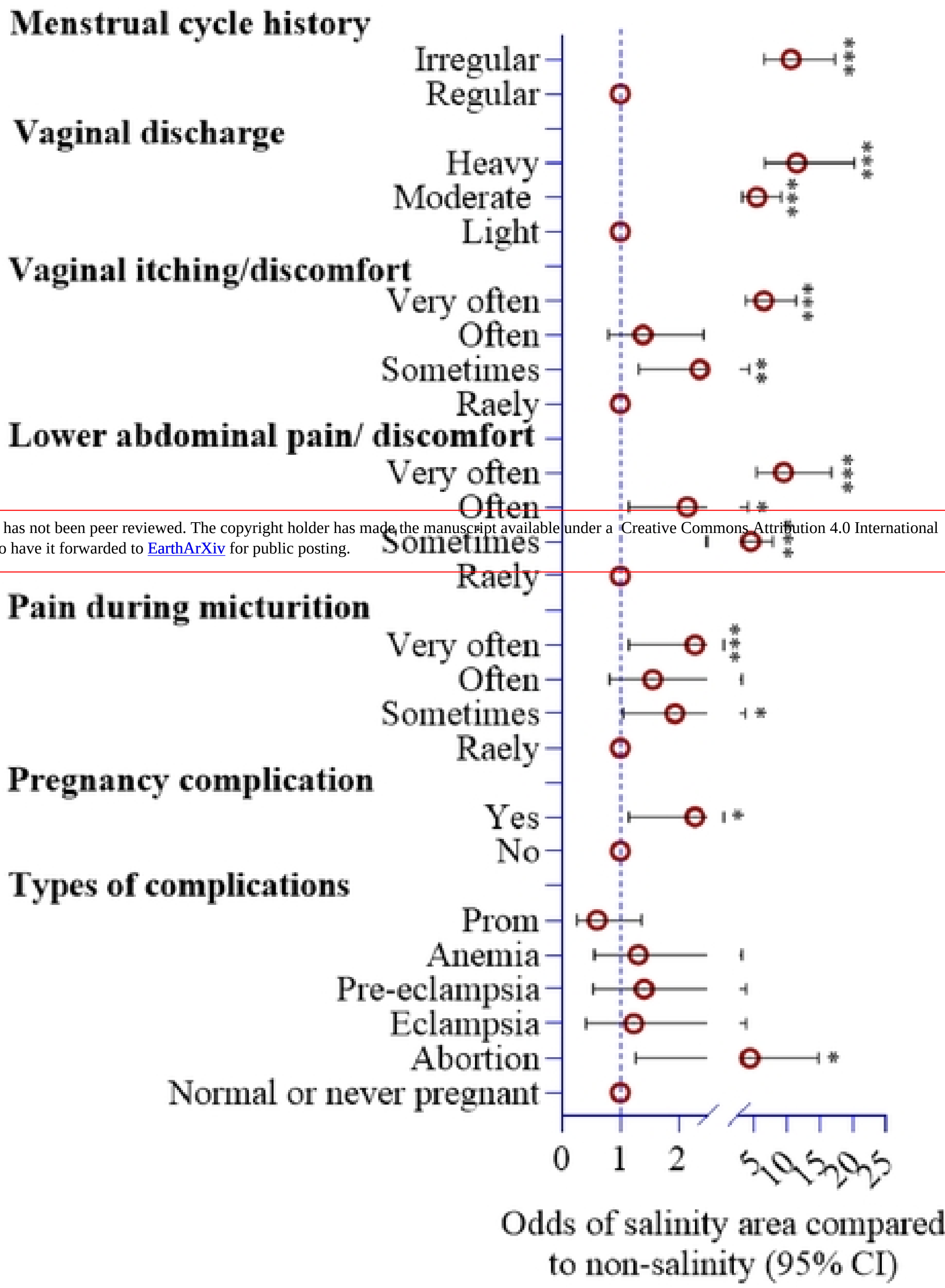




Figure 1. The risk of Salinity on Menstrual and Reproductive Health compared to non-salinity area's participants. To estimate the odds ratio and p-value we used ordinal logistic regression for binary observations and multinomial logistic regression for ordinal observations.

The mean pH level was significantly lower ($p<0.001$) in the source water of salinity area (6.99±0.14) compared to non-salinity area (7.55±0.14) (Figure 2)

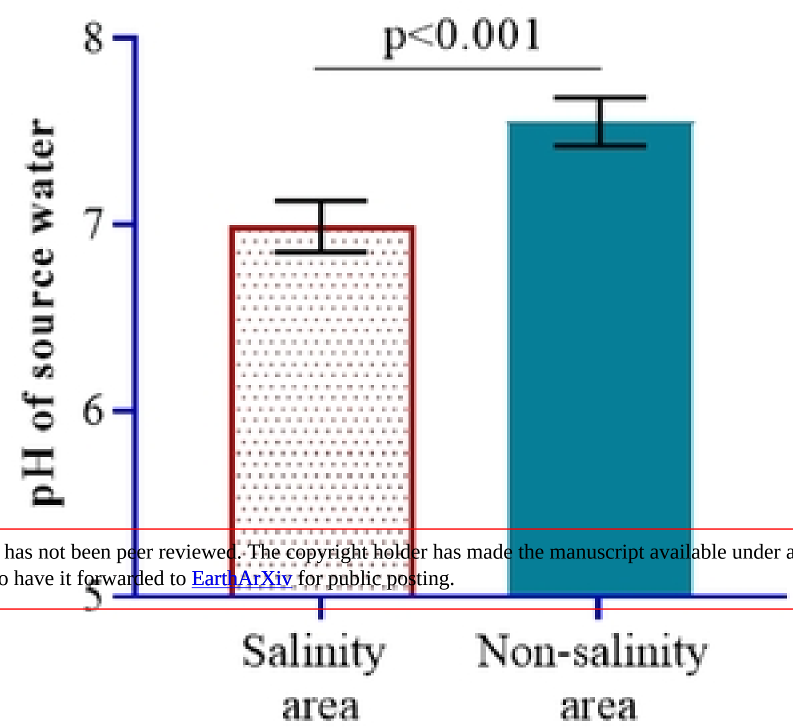




**Figure 2.** Difference in pH levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.

Average concentration of salinity showed significantly higher ($p<0.001$) in the source water of salinity area (2.19±0.72) compared to non-salinity area (0.05±0.01) (Figure 3).

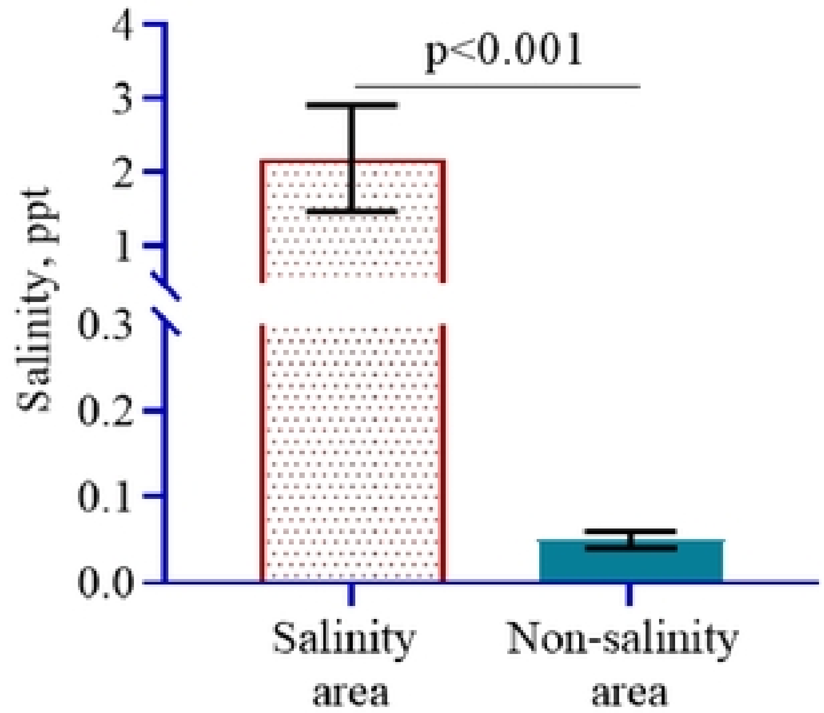


**Figure 3.** Difference in salinity levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.

Similar to concentration of salinity the electrical conductivity (EC) also showed significantly higher ($p<0.001$) in the source water of salinity area (3415.0±1124.0) compared to non-salinity area (203.0±17.0) (Figure 4).

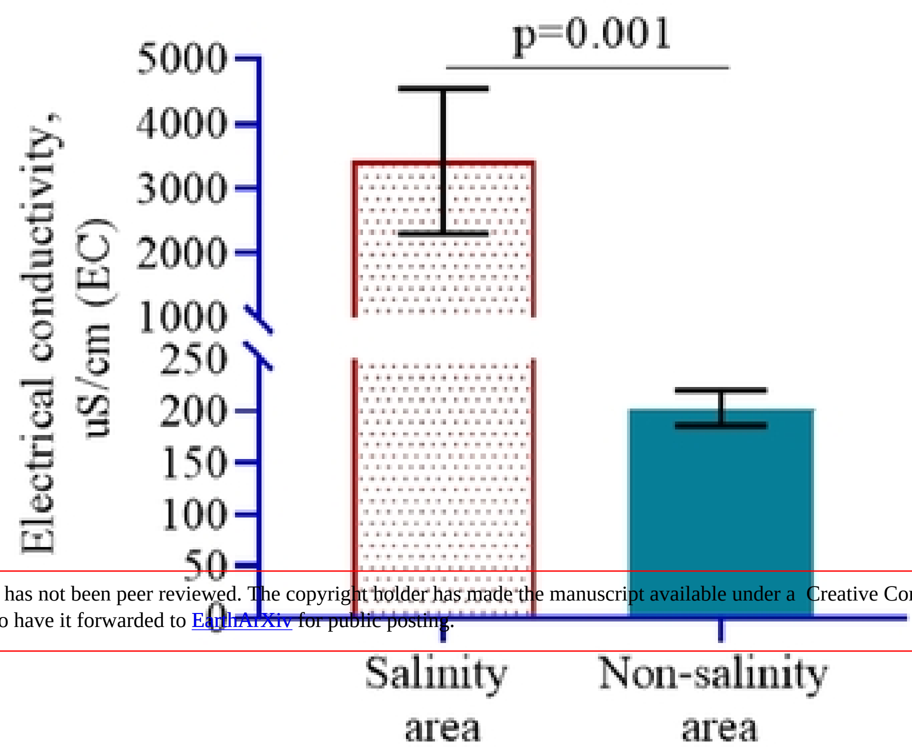




**Figure 4.** Difference in electrical conductivity (EC) levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.

Total dissolved solids (TDS) also revealed significantly ($p<0.001$) higher concentrations of the source water of the salinity area (2185.0±719.5) compared to non-salinity area (129.3±10.7) (Figure 5)

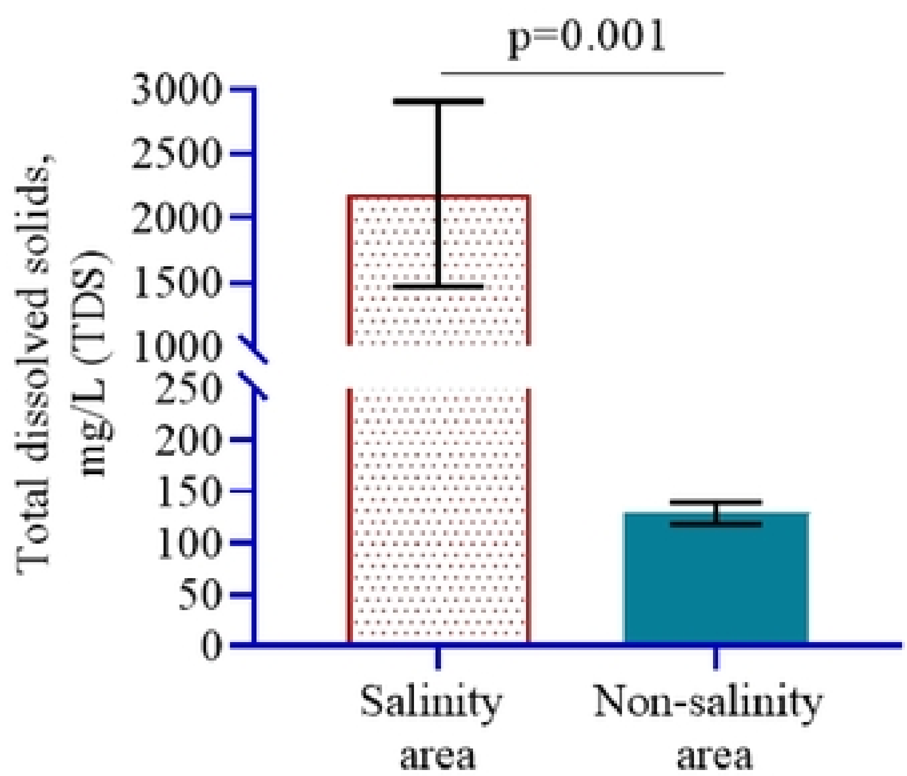


**Figure 5.** The difference in total dissolved solids (TDS) levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.