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

The majority of Bangladesh's coastal regions are most severely affected by saline intrusion, another common aspect of the country's environmental problems[1]. Water salinity is exacerbated by several natural and man-made factors, which restrict freshwater supplies, agricultural practices, human health, and overall means of subsistence[1]. The country's distinct geographic and climatic characteristics, the rising sea level, and unsustainable practices all contribute to these effects[2]. Nonetheless, environmental preservation is a problem that calls for an international strategy. It is an urgent problem that demands cooperation and shared accountability[2]. Numerous working factors that help in understanding the causes have been identified as a result of recent extensive research on the salinity issue[3]. Coastal aquifers in the Bay of Bengal cause salinity intrusion that affects Bangladesh. Rising sea levels brought on by global climate change[4,5] allow seawater to move farther inland during the dry season when river flows are reduced. The situation is made worse by the increase in groundwater use for daily needs and farming, especially in urban areas, which lowers the freshwater table and makes it more vulnerable to invasion by saltwater[2,4]. Human activities that alter the natural equilibria of fresh and saltwater bodies, such as the shrimp aquaculture operations along the coast, also

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worsen salinity intrusion[6]. Climate change has harmed rainfall patterns, resulting in a decrease in freshwater river discharges and dry season rainfall that are intended to protect areas from salty water. Bangladesh's rate of salinity progression has accelerated as a result of these interrelated factors[6,7]. According to data from Bangladesh's Soil Resources Development Institute (SRDI), the number of saline areas increased by 132% between 1973 and 2009. Southeast and southwest regions of Bangladesh, including Chattogram, Patuakhali, Noakhali, Bagerhat, Khulna, Satkhira, and Cox's Bazar[8], are becoming more vulnerable due to increased climatic variability and a rapidly expanding population. By any measure, the prospect of future migration due to salinity intrusion is terrifyingly catastrophic, as about 35 million people in coastal Bangladesh are at risk of sea level rise and salinity as a result of urbanization, population growth, and climate change[9]. Saline water is a major threat to inland farmers and the agricultural sector since most people live in rural areas and depend on agriculture, which is crucial to food security[8,9]. Salinity intrusion significantly reduces agricultural productivity because it impacts soil fertility and crop health in general[9]. Farmers are compelled to switch to less lucrative crops to grow rice, a traditional crop that needs a lot of freshwater. Aquaculture activities also benefit from salt-tolerant crops, which reduce biodiversity as many freshwater species are replaced by them[11]. This indicates that humans are both directly and indirectly threatened by salinity in water. Consuming saline water has been linked in studies to an increased risk of hypertension, primarily in pregnant women. During the dry season, when freshwater resources are limited, salinity also contributes to the development of skin infections, cholera, and diarrhea[11,12]. In these areas, salinity has also led to stunted growth and infant mortality[12,13,14]. The insecurity of socioeconomic status is another reason to understand the effects of saltwater intrusion. Due to water scarcity, people are forced to use costly sources like bottled water or travel great distances, which is time-consuming and costly[11].

In addition, saline water causes houses and roads to deteriorate structurally. These issues hinder the development of coastal areas and exacerbate poverty. As a result, many of the most vulnerable populations wind up trapped in a cycle of poverty[14,15]. Several low-lying deltaic countries close to sea level, including Bangladesh, are severely impacted by displacement brought on by climate change along their coastlines[10]. Among the many phenomena linked to climate change, the sea level rise in Bangladesh's coastal region is one of the most common, reversible, and potentially dangerous ones[1]. Rising salinity levels in soil and water bodies are a threat to general health, and reproductive health in particular, in addition to hindering agriculture and livelihoods1[2,16]. The study, which looks at fertility problems associated with the salinity concentration in Bangladesh's coastal region, was limited to the two unions of Koyra Upazila, Uttar Bedkashi, and Dakhin Bedkashi from Khulna district. Even though these issues are intertwined in social contexts, there are obvious health problems related to the menstrual cycle of coastal women, such as stress on mental health, hygiene, and managing the menstrual cycle effectively[16,18]. Compared to men, women are frequently the ones who suffer the most when there is a food shortage in the home[17,18]. Because saline water is used for these purposes, women in coastal areas have difficulties managing their periods, even when performing basic sanitation tasks[19,20]. Their sensitive areas are irritated by saltwater, which can lead to menstrual flow discomfort and urinary tract and vaginal infections[21]. In a similar vein, excessive saline water consumption seriously impairs a woman's reproductive health[19,21]. Sixty-six percent of coastal women and girls who are impacted by salinity[19] suffer from abdominal and pelvic inflammatory diseases. Particularly in low-income countries, pregnancy-related hypertensive disorders are a leading cause of maternal and neonatal mortality[22]. Pre-eclampsia is one of the top five direct causes of maternal deaths[22,23]. Additionally, it raises the risk of intrauterine growth restriction and preterm birth, results in high blood pressure (BP) in offspring of afflicted mothers, and raises the mother's future risk of cardiovascular disease[24,25]. A high salt intake raises the risk of hypertension in both adults and children, according to compelling epidemiological evidence[26]. The impact of salt on the development of hypertensive disorders during pregnancy, however, is not well understood, according to a Cochrane review[27,28]. According to a 2008 survey[29], pre-eclampsia and gestational hypertension were also more common along Bangladesh's coast than in its non-coastal regions. In addition, the rates were exceptionally high during the dry season, when surface and groundwater salinity concentrations are higher than during the monsoon season[30,31,32]. This is because the approximately 40 million people who live along Bangladesh's coast rely on ponds, rivers, and tube wells

for their drinking water[30]. Due to anthropogenic factors like water management and shrimp aquaculture[33], as well as seawater intrusion brought on by climate change, these sources are already extremely salinized[32]. Sea level rise brought on by climate change and excessive groundwater withdrawals from aquifers are expected to exacerbate the effects of salinity, which has already spread more than 100 kilometers inland from the Bay of Bengal[34,35]. Because fresh water is scarce in certain areas, females tend to drink more salinized water, which results in high sodium intake[36]. Because too much sodium in the body causes dehydration, this long-term exposure damages the body by changing the normal fluid balance. Urine concentration rises as a result of dehydration, which promotes bacterial growth in the person's urinary system[37]. Additionally, drinking too little water slows down the rate at which urine is produced, which impairs the body's ability to cleanse the urinary tract and increases the risk of UTIs[38]. The kidneys are under pressure to remove a lot of sodium from the body because of the high salt content. Because the increased urine concentration speeds up the process of crystal clumping[39], this stress may increase the risk of developing renal stones. Kidney stones increase the risk of UTI by obstructing urine flow and promoting bacterial growth in the urinary tract. 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[40,41,42,43]. This research aims to understand how high salinity levels in coastal regions affect women's health, especially in comparison to non-coastal areas where salinity is low or absent. In coastal regions, women often use saline water for daily needs, which negatively affects menstrual hygiene, leading to discomfort, urinary and vaginal infections, and increased risks during pregnancy, such as high blood pressure and complications like pre-eclampsia. By showing these health differences between coastal and non-coastal women, the study calls for urgent action, such as improving access to safe water, raising awareness, and ensuring better maternal healthcare, to protect the reproductive health of women living in salinity-affected areas.

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^{2+})
7. Magnesium (Mg^{2+})
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)	

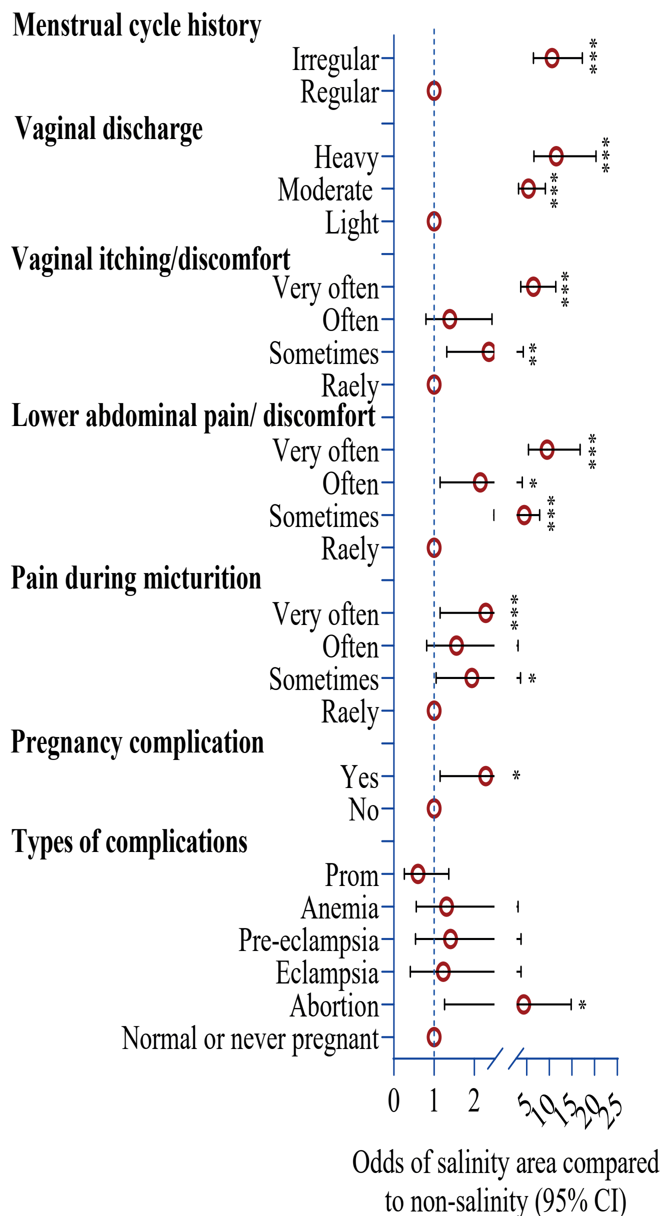

Figure 1. The risk of Salinity on Menstrual and Reproductive Health compared to non-salinity area's participants. To estimate the odds ratio and p-value we used ordinal logistic regression for binary observations and multinomial logistic regression for ordinal observations.

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)

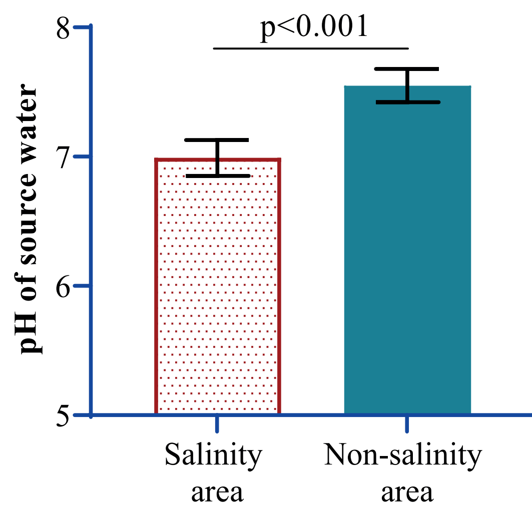

Figure 2. Difference in pH levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.

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).

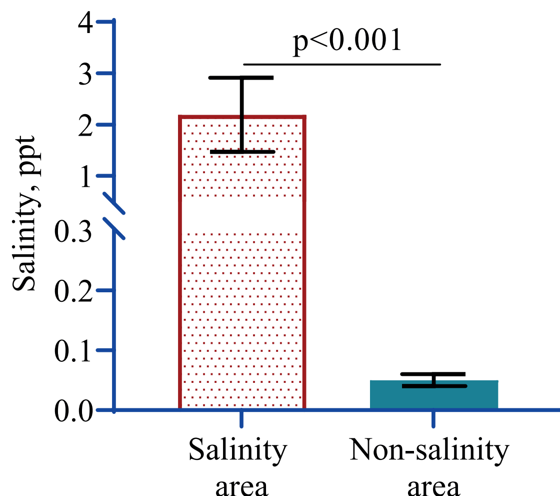

Figure 3. Difference in salinity levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.

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).

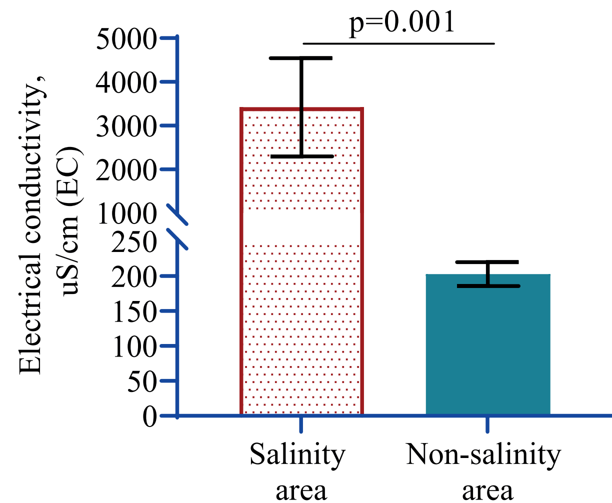

Figure 4. Difference in electrical conductivity (EC) levels of the source water between the salinity and non-salinity area. Mann-Whitney U test was used to estimate the p-value.

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[43,44]. Pregnancy complications like miscarriages, eclampsia, pre-eclampsia, anemia, and premature membrane rupture are more common in women living in high-salinity areas. This postulates a positive relationship between exposure to salinity and poor reproductive outcomes[45].

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[46,47].

- ✓ Oxidative Stress: The application of salinity causes oxidative stress, which affects cells and tissues[48,49,50]. Reproductive health; oxidative stress produces low-quality eggs and sperm, reducing women's chances of becoming pregnant or having complicated pregnancies[51,52].
- ✓ Inflammation: Chronic exposure to salinity leads to inflammation in the body[53]. Inflammation processes can act on the reproductive organs and cause PID and endometriosis[54].
- ✓ Nutritional Deficiencies: The amount of nutrients required for crops and, by extension, for the diet is restricted because salt can increase the degree of binding between the soil and water molecules[55,56]. The female reproductive cycle may also be impacted by several nutrients, particularly folic acid and iron deficiency[57,58].

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[30]. 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 [30,59,60,68]

Water quality's significance and effects

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[61-63,67]. 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 genitourinary tract infections[64,65,66].

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, policymakers, health officials, and researchers can all come together to enhance the reproductive health of women in Bangladesh's coastal regions and other comparable places.

Limitations of the Study

To fully understand the results about how salinity affects menstrual and reproductive health, one must take into account the limitations of this study. The cross-sectional design limits the ability to draw conclusions about causality. Furthermore, the problems of common method variance can make using survey data problematic. To expand on the findings in the future, longitudinal research designs with more precise exposure and health effect assessments are needed.

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.

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Conflict of interest

The authors declare that there is no conflict of interest.

Ethical clearance

Ethical approval for this study was obtained from the Research and Innovation Centre of Khulna University with the reference number: KUECC-2025-01-01

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

REFERENCES

1. Chakraborty R, Khan KM, Dibaba DT, Khan MA, Ahmed A, Islam MZ. Health Implications of Drinking Water Salinity in Coastal Areas of Bangladesh. *International Journal of Environmental Research and Public Health [Internet]*. 2019 Oct 4;**16**(19):3746. https://doi.org/10.3390/ijerph16193746
2. Alam MZ, Carpenter-Boggs L, Mitra S, Haque MdM, Halsey J, Rokonuzzaman M, et al. Effect of Salinity Intrusion on Food Crops, Livestock, and Fish Species at Kalapara Coastal Belt in Bangladesh. *Journal of Food Quality [Internet]*. 2017 Jan 1; 2017:1–23. https://doi.org/10.1155/2017/2045157
3. Bannari A, Al-Ali ZM. Assessing Climate Change Impact on Soil Salinity Dynamics between 1987–2017 in Arid Landscape Using Landsat TM, ETM+ and OLI Data. Remote Sensing [Internet]. 2020 Aug 28;12(17):2794. https://doi.org/10.3390/rs12172794
4. Ashrafuzzaman M, Artemi C, Santos FD, Schmidt L. Current and Future Salinity Intrusion in the South-Western Coastal Region of Bangladesh. *Spanish Journal of Soil Science [Internet]*. 2022 Mar 21;**12**. https://doi.org/10.3389/sjss.2022.10017
5. Fedosiuk, K. ., Pakharenko, L. ., Chayka, K. ., Basiuha, I. ., & Kurtash, O. . (2023). Abnormal uterine bleeding in women of reproductive age: PALM-COEIN causes. *Bangladesh Journal of Medical Science*, **22**(4):809–814. https://doi.org/10.3329/bjms.v22i4.67116
6. Shaibur MR, Parvin S, Ahmmed I, Rahaman MdH, Das TK, Sarwar S. Gradients of salinity in water sources of Batiaghata, Dacope and Koyra Upazila of coastal Khulna district, Bangladesh. *Environmental Challenges [Internet]*. 2021 May 17; **4**:100152. https://doi.org/10.1016/j.envc.2021.100152
7. Akter T, Jhohura FT, Akter F, Chowdhury TR, Mistry SK, Dey D, et al. Water Quality Index for measuring drinking water quality in rural Bangladesh: a cross-sectional study. *Journal of Health Population and Nutrition [Internet]*. 2016 Feb 9;**35**(1): https://doi.org/10.1186/s41043-016-0041-5
8. Lam Y, Winch PJ, Nizame FA, Broaddus-Shea ET, Harun MdGD, Surkan PJ. Salinity and food security in southwest coastal Bangladesh: impacts on household food production and strategies for adaptation. *Food Security [Internet]*. 2021 Jul 29;**14**(1):229–48. https://doi.org/10.1007/s12571-021-01177-5
9. Brammer, H. (2014). Bangladesh's Dynamic Coastal Regions and Sea-Level Rise. *Clim. Risk Manage.* 1, 51–62. doi:10.1016/j.crm.2013.10.001
10. Jabed MdA, Paul A, Nath TK. Peoples' Perception of the Water Salinity Impacts on Human Health: A Case Study in South-Eastern Coastal Region of Bangladesh. *Exposure and Health [Internet]*. 2018 Jun 18;**12**(1):41–50. https://doi.org/10.1007/s12403-018-0283-0
11. Shammi M, Rahman MdM, Bondad SE, Bodrud-Doza Md. Impacts of Salinity Intrusion in Community Health: A Review of Experiences on Drinking Water Sodium from Coastal Areas

of Bangladesh. *Healthcare [Internet]*. 2019 Mar 22;**7**(1):50. https://doi.org/10.3390/healthcare7010050

12. Nahian MA, Ahmed A, Lázár AN, Hutton CW, Salehin M, Streatfield PK. Drinking water salinity associated health crisis in coastal Bangladesh. *Elementa Science of the Anthropocene [Internet]*. 2018 Jan 1;**6**: https://doi.org/10.1525/elementa.143
13. Saadi, R. K., Alobaidy, E. J. ., & Ibrahim, H. K. . (2023). Evaluation of Some Serological Indicators in Women with Polycystic Ovary Syndrome in Baquba , Iraq. *Bangladesh Journal of Medical Science*, **22**(20): 4–9. https://doi.org/10.3329/bjms.v22i20.66300
14. Hossain PR, Ludwig F, Leemans R. Adaptation pathways to cope with salinization in south-west coastal region of Bangladesh. *Ecology and Society [Internet]*. 2018 Jan 1;**23**(3): https://doi.org/10.5751/es-10215-230327
15. Hoque MA, Scheelbeek PFD, Vineis P, Khan AE, Ahmed KM, Butler AP. Drinking water vulnerability to climate change and alternatives for adaptation in coastal South and South East Asia. *Climatic Change [Internet]*. 2016 Feb **24**;136(2):247–63. https://doi.org/10.1007/s10584-016-1617-1
16. Hasan MdH, Hossain MJ, Chowdhury MdA, Billah M. Salinity Intrusion in Southwest Coastal Bangladesh: An Insight from Land Use Change. In: *Springer eBooks [Internet]*. 2020. p. 125–40. https://doi.org/10.1007/978-3-030-47786-8_8
17. Alston, M. Women and Climate Change in Bangladesh. USA: Routledge.2015;1st Edition.
18. Roy, T., Chandra, D., Sony, M. M. A. A. M. and Rahman, M. S. Impact of salinity intrusion on the health of coastal people: Reflections from Dacope Upazila of Khulna district, Bangladesh. *Khulna University Studies.* 2021;**17**(1 & 2): 57–66
19. Zaman, F. Impact of salinity on poor coastal people's health: Evidence from two coastal villages in Bangladesh. *Journal of the Asiatic Society of Bangladesh (Hum.).* 2017;**62**(1), 1–14.
20. Chowdhury, F. A. and June, F. K. Programme Progress Report 2016–2020: Water, Sanitation and Hygiene, BRAC Survey Report, Bangladesh.2021
21. Khanam, D. and Dina, S. A. Water salinity, menstrual health and human rights of coastal adolescent girls of Bangladesh: A story of misery. *Jus Humanis Journal of International Human Rights Law.* 2020;**3**: 69–75.
22. Firoz T, Fellow MD, Sanghvi H, Merialdi M, von Dadelszen P. Pre-eclampsia in low- and middle-income countries. Best Practice & Research Clinical Obstetrics and Gynaecology. 2011;25: 537–548.
23. Khan KS, Wojdyla D, Say L, Gulmezoglu AM, Van Look PF. *WHO analysis of causes of maternal death: a systematic review*. 2006; Lancet **367**(9516): 1066–1074.
24. Macdonald-Wallis C, Tilling K, Fraser A, Nelson SM, Lawlor DA. Established preeclampsia risk factors are related to patterns of blood pressure change in normal term pregnancy: findings from the Avon Longitudinal Study of Parents and Children. *J Hypertens.* 2011;**29**(9): 1703–1711.
25. Sibai BM. Chronic hypertension in pregnancy. *Obstet Gynecol.* 2002;**100**(2): 369–377.
26. He FJ, Macgregor GA. A comprehensive review on salt and health and current experience of worldwide salt reduction programmes. *J Hum Hypertens.* 2009;**23**(6): 363–384.
27. Singal, N., Setia, G., Taneja, B. K., & Singal, K. K. Maternal outcome in pregnant women with anaemia. *Bangladesh Journal of Medical Science*, 2018; **17**(3): 446–454. https://doi.org/10.3329/bjms.v17i3.37001
28. Duley L, Henderson-Smart D, Meher S. Altered dietary salt for preventing pre-eclampsia, and its complications. *Cochrane Database Syst Rev*. 2005;**4**: CD005548.
29. Khan A, Mojumder SK, Kovats S, Vineis P. Saline contamination of drinking water in Bangladesh. *Lancet*.2008;**371**(9610): 385.
30. Khan AE, Ireson A, Kovats S, Mojumder SK, Khusru A, et al.Drinking Water Salinity and Maternal Health in Coastal Bangladesh: Implications of Climate Change. *Environ Health Perspect*.2011;**119**: 1328–1332.
31. Ahmad, A. ., Khatoon, F. ., Nishad, S. ., Saambhavi, .-., & Sonam, S. Exploring the incidence and causes of cesarean Delivery : Partially Mixed Concurrent quantitative and Qualitative analysis from a Medical College. *Bangladesh Journal of Medical Science*, 2022; **21**(2): 284–290. https://doi.org/10.3329/bjms.v21i2.58060
32. Rahman AA, Ravenscroft P.Groundwater Resources and Development in Bangladesh: Background to the Arsenic Crisis, Agricultural Potential And the Environment. Dhaka: The University Press. The University Press.2003
33. Ministry of Environment and Forest B. Impact of Sea-Level Rise on Land Use Suitability and Adaptation Options: Coastal Land Zoning in the Southwest.2006
34. Kundzewicz ZW, Mata LJ, Arnell NW, Doll P, Jimenez B, et al. The implications of projected climate change for freshwater resources and their management. *Hydrological Sciences Journal*.2009; **53**: 1, 3–10.
35. Ferdaus F, Begum S. HEALTH AND ECONOMIC IMPACTS OF CLIMATE CHANGE IN RURAL BANGLADESH AND OPTIONS TO GO THROUGH. *Khulna University Studies* 2023:25–9. https://doi.org/10.53808/kus.si.2023.ices.a24-ls.
36. Ferdaus F. Knowledge and Practice of Drinking Safe Water Among the Community People of Horintana, Khulna. *Anwer Khan Modern Medical College Journal* 2019;**10**:105–9. https://doi.org/10.3329/akmmcj.v10i2.44117.
37. Perrier ET, Armstrong LE, Bottin JH, Clark WF, Dolci A,

Guelinckx I, Iroz A, Kavouras SA, Lang F, Lieberman HR, Melander O, Morin C, Seksek I, Stookey JD, Tack I, Vanhaecke T, Vecchio M, Péronnet F. Hydration for health hypothesis: a narrative review of supporting evidence. *Eur J Nutr.* 2021 Apr;**60**(3):1167-1180. doi: 10.1007/s00394-020-02296-z. Epub 2020 Jul 6. PMID: 32632658; PMCID: PMC7987589.

38. El-Sharkawy AM, Sahota O, Lobo DN. Acute and Chronic Effects of Hydration Status on Health. Nutrition Reviews [Internet]. 2015 Aug 19;**73**(2):97–109. Available from: https://academic.oup.com/nutritionreviews/article/73/suppl_2/97/1930742
39. Ripa F, Pietropaolo A, Montanari E, Hameed BMZ, Gauhar V, Somani BK. Association of Kidney Stones and Recurrent UTIs: the Chicken and Egg Situation. A Systematic Review of Literature. *Current Urology Reports [Internet].* 2022 Jul 25;**23**(9):165–74. Available from: https://doi.org/10.1007%2Fs11934-022-01103-y
40. Begum, T., & Reza, F. Auditory Cognitive Function Assessment during Pregnancy: An Event-Related Potential and Neuropsychological Study. *Bangladesh Journal of Medical Science*, 2021;**20**(3): 608–617. https://doi.org/10.3329/bjms.v20i3.52803
41. National Kidney Foundation. Urinary Tract Infections [Internet]. National Kidney Foundation. 2024. Available from: https://www.kidney.org/kidney-topics/urinary-tract-infections
42. The Link Between Urinary Tract Infection and Kidney Stones [Internet]. Panoramic Health. 2024
43. Sinha S, Ahmad R, Chowdhury K, Ferdaus F, Banik S, Mehta M, et al. The Impact of Saline Water on Women's Health in the Coastal Region of Bangladesh: Special Attention on Menstrual Hygiene Practices. Cureus [Internet]. 2024 Aug 16; Available from: https://doi.org/10.7759/cureus.67032
44. Climate change's devastating toll: Salinity's impact on coastal women's health in Bangladesh [Internet]. Available from: https://asia.fes.de/news/bangladesh-coastal-women.html
45. Population Council. Drinking Water Salinity and Risk of Pre-eclampsia and Eclampsia – Population Council [Internet]. Population Council – Ideas. Evidence. Impact. 2024. Available from: https://popcouncil.org/project/development-of-pre-eclampsia-and-eclampsia-in-relation-to-drinking-water-salinity-in-coastal-bangladesh/
46. Wang G, Yeung CK, Zhang JL, Hu XW, Ye YX, Yang YX, et al. High salt intake negatively impacts ovarian follicle development. Annals of Anatomy - Anatomischer Anzeiger [Internet]. 2015 Mar **12**;200:79–87. Available from: https://doi.org/10.1016/j.aanat.2015.02.009
47. Abdelnour SA, El-Hack MEA, Noreldin AE, Batiha GE, Beshbishy AM, Ohran H, et al. High Salt Diet Affects the Reproductive Health in Animals: An Overview. *Animals [Internet].* 2020 Mar 31;**10**(4):590. Available from: https://doi.org/10.3390/ani10040590
48. Matlala, S. F. (2020). Concealed pregnancy among school-going adolescents in South Africa: A qualitative study on risks for maternal and child health. *Bangladesh Journal of Medical Science*, **19**(4): 620–624. https://doi.org/10.3329/bjms.v19i4.46616
49. Hasanuzzaman M, Raihan MdRH, Masud AAC, Rahman K, Nowroz F, Rahman M, et al. Regulation of Reactive Oxygen Species and Antioxidant Defense in Plants under Salinity. *International Journal of Molecular Sciences [Internet].* 2021 Aug 28;**22**(17):9326. Available from: https://doi.org/10.3390/ijms22179326
50. Parihar P, Singh S, Singh R, Singh VP, Prasad SM. Effect of salinity stress on plants and its tolerance strategies: a review. *Environmental Science and Pollution Research [Internet].* 2014 Nov 15;**22**(6):4056–75. Available from: https://doi.org/10.1007/s11356-014-3739-1
51. Ruder EH, Hartman TJ, Goldman MB. Impact of oxidative stress on female fertility. *Current Opinion in Obstetrics & Gynecology [Internet].* 2009 May 21;**21**(3):219–22. Available from: https://doi.org/10.1097/gco.0b013e32832924ba
52. Agarwal A, Aponte-Mellado A, Premkumar BJ, Shaman A, Gupta S. The effects of oxidative stress on female reproduction: a review. *Reproductive Biology and Endocrinology [Internet].* 2012 Jan 1;**10**(1):49. Available from: https://doi.org/10.1186/1477-7827-10-49
53. Basdeki E, Kollias A, Mitrou P, Tsirimiagkou C, Georgakis M, Chatzigeorgiou A, et al. Does Sodium Intake Induce Systemic Inflammatory Response? A Systematic Review and Meta-Analysis of Randomized Studies in Humans. *Nutrients [Internet].* 2021 Jul 30;**13**(8):2632. Available from: https://doi.org/10.3390/nu13082632
54. Weiss G, Goldsmith LT, Taylor RN, Bellet D, Taylor HS. Inflammation in Reproductive Disorders. *Reproductive Sciences [Internet].* 2009 Feb 1;**16**(2):216–29. Available from: https://doi.org/10.1177/1933719108330087
55. Bidalia A, Vikram K, Yamal G, Rao KS. Effect of Salinity on Soil Nutrients and Plant Health. In: Springer eBooks [Internet]. 2019. p. 273–97. Available from: https://doi.org/10.1007/978-981-13-8801-9_13
56. Fageria NK, Gheyi HR, Moreira A. NUTRIENT BIOAVAILABILITY IN SALT AFFECTED SOILS. *Journal of Plant Nutrition [Internet].* 2011 Apr 30;**34**(7):945–62. Available from: https://doi.org/10.1080/01904167.2011.555578
57. Cueto HT, Riis AH, Hatch EE, Wise LA, Rothman KJ, Sørensen HT, et al. Folic acid supplement use and menstrual

cycle characteristics: a cross-sectional study of Danish pregnancy planners. *Annals of Epidemiology [Internet].* 2015 Jun 5;**25**(10):723-729.e1. Available from: https://doi.org/10.1016/j.annepidem.2015.05.008

58. Ndiaye NF, Idohou-Dossou N, Diouf A, Guiro AT, Wade S. Folate Deficiency and Anemia Among Women of Reproductive Age (15-49 Years) in Senegal: Results of a National Cross-Sectional Survey. *Food and Nutrition Bulletin [Internet].* 2017 Nov 12;**39**(1):65–74. Available from: https://doi.org/10.1177/0379572117739063
59. Nahian MA, Ahmed A, Lázár AN, Hutton CW, Salehin M, Streatfield PK. Drinking water salinity associated health crisis in coastal Bangladesh. *Elementa Science of the Anthropocene [Internet].* 2018 Jan 1;6. Available from: https://doi.org/10.1525/elementa.143
60. Shaibur MR, Parvin S, Ahmmed I, Rahaman MdH, Sarwar S. Climate Change and Salinity Intrusion in the Water Sources of Coastal Khulna District, Bangladesh. In: Advances in Science, Technology & Innovation/Advances in science, technology & innovation [Internet]. 2022. p. 123–6. Available from: https://doi.org/10.1007/978-3-031-00808-5_29
61. Shammi M, Rahman MdM, Bondad SE, Bodrud-Doza Md. Impacts of Salinity Intrusion in Community Health: A Review of Experiences on Drinking Water Sodium from Coastal Areas of Bangladesh. *Healthcare [Internet].* 2019 Mar 22;**7**(1):50. Available from: https://doi.org/10.3390/healthcare7010050
62. Islam MR. A Study on the TDS Level of Drinking Mineral Water in Bangladesh. *American Journal of Applied Chemistry [Internet].* 2016 Jan 1;**4**(5):164. Available from: https://doi.org/10.11648/j.ajac.20160405.11
63. Talukder MRR, Rutherford S, Huang C, Phung D, Islam MZ, Chu C. Drinking water salinity and risk of hypertension: A systematic review and meta-analysis. *Archives of Environmental & Occupational Health [Internet].* 2016 Apr 11;**72**(3):126–38. Available from: https://doi.org/10.1080/19338244.2016.1175413
64. Ahmad MM, Saqib SE. Salinity and the health of the poor in coastal Bangladesh. In: Elsevier eBooks [Internet]. 2021. p. 563–75. Available from: https://doi.org/10.1016/b978-0-323-85195-4.00012-3
65. Naser AM, Rahman M, Unicomb L, Doza S, Ahmed KM, Uddin MN, et al. Drinking water salinity and kidney health in southwest coastal Bangladesh: baseline findings of a community-based stepped-wedge randomized trial. *The Lancet [Internet].* 2017 Apr 1;**389**:S15. Available from: https://doi.org/10.1016/s0140-6736(17)31127-3
66. Rakova N, Kitada K, Lerchl K, Dahlmann A, Birukov A, Daub S, et al. Increased salt consumption induces body water conservation and decreases fluid intake. *Journal of Clinical Investigation [Internet].* 2017 Apr 16;**127**(5):1932–43. Available from: https://doi.org/10.1172/jci88530
67. KUSBARYANTO, -; CHAPSOH, -. The Effectiveness of Education with Picture Media to Increase Students' Knowledge and Attitudes about Maintaining the Cleanliness of the External Genitalia at Al-Azhar26 Junior High School Yogyakarta. *International Journal of Human and Health Sciences (IJHHS),* may 2024;**8**(2): p. 157-164,. ISSN 2523-692X. Available at: <https://ijhhsfimaweb.info/index.php/IJHHS/article/view/637>. Date accessed: 05 may 2025. doi:http://dx.doi.org/10.31344/ijhhs.v8i2.637.
68. DAUD, Nur Aizati Athirah et al. 'Oh Bulan' Pilot Project: Sanitary Pad Usage and School Absenteeism During Menstruation Among Adolescent Girls in Rural Kelantan. *International Journal of Human and Health Sciences (IJHHS),* [S.l.] july 2024;**49**: dec. 2019. ISSN 2523-692X. Available at: <https://www.ijhhsfimaweb.info/index.php/IJHHS/article/view/167>. Date accessed: 27. doi:http://dx.doi.org/10.31344/ijhhs.v0i0.167.