Published with Open Access at Journal BiNET
Vol. 29, Issue 01: 2416-2425
Journal of Bioscience and Agriculture Research
Journal Home: www.journalbinet.com/jbar-journal.html

Salinity: A chain to be assessed

Purba Islam[1], Popy Khatun[1] and Arup Islam[2]

[1]Department of Pharmacology, Faculty of Veterinary Science, Bangladesh Agricultural University, Bangladesh
[2]Department of Microbiology, Mymensingh Medical College, Bangladesh

✉ For any information: purba.islam@bau.edu.bd (Islam, P)
Article received: 03.04.2022; Revised: 25.06.2022; First published online: 30 July 2022

ABSTRACT

Salinity intrusion is a major problem, particularly in the coastal area of Bangladesh. This review aims to know the development, present scenario, causes, detection technique, impact and management of salinity intrusion in Bangladesh to assess the salinity chain. Salinity has numerous direct and indirect impacts like hypertension, eclampsia and diarrhoea in humans derived from drinking water, crops, livestock and fish from the affected areas. Salinity affects human life, livelihood, health and well-being and is also closely linked with ecosystems that hamper food production. By decreasing crop, livestock and fish yield, salinity intrusion continuously leads the nation to food insecurity. To overcome salinity intrusion, some management ways are also discussed here.

Key Words*: Salinity, Causes, Detection technique, Impacts and Management*

Cite Article: Islam, P., Khatun, P. and Islam, A. (2022). Salinity: A chain to be assessed. Journal of Bioscience and Agriculture Research, 29(01), 2416-2425.
Crossref: https://doi.org/10.18801/jbar.290122.293

I. Introduction

Bangladesh is a riverine country bounded south by the Bay of Bengal (Ahsan, 2013). The southern regions of Bangladesh cover about 32% of the country and are only a few meters above sea level (Shammi et al., 2019). Due to natural and anthropogenic causes, sea levels rise day by day. The rising sea level and many natural hazards such as storms, cyclones and inundation have contributed to developing salinity intrusion (Ahmed et al., 2017). Salinity intrusion is a global problem, especially in coastal regions. In recent years, Bangladesh has been experiencing a higher rate of salinity intrusion (Vineis et al., 2011). Salinity intrusion is the accumulation of salt in land and water to a level that impacts the natural and built environment (Alam et al., 2017). As salinity levels in the water and soil increase rapidly, the south-west region's people suffer many ecological problems (Ahsan, 2010). Salinity levels above a certain threshold have several direct and indirect impacts on safe drinking water, crops, livestock and fish production (Irfan and Hayat, 2011). Human life, livelihood, health and well-being are closely linked with the ecosystems and the increasing problem adversely affects productivity, socio-economic impact and overall livelihood strategies (Ahmed et al., 2017; Berge and Cunha, 1993).

Published with open access at journalbinet.com
EISSN: 2312-7945, ©2022 The Authors, Review paper

Livestock's survival depends on the field grass, water and feed. Under grazing conditions, animals may ingest excessive salt through feed, drinking water and soil. Excessive intake of salt is one of the common problems that often cause loss of appetite and reduced milk production and growth. Many studies have found that the scarcity of safe drinking water, along with salinity containing grass and feed, has adverse effects on farm animals' performance, carcass traits and meat quality (Abdelsattar et al., 2020; Ru and Glatz, 2004).

At the same time, the demand for food increases daily with the steady increase in the human population (Alam et al., 2014). Greater levels of gestational hypertension were discovered in pregnant women on the south-western coast of Bangladesh compared to noncoastal pregnant women because of the connection between agricultural products and human livelihood. It was hypothesized to be caused by saline water, crops and livestock products (DoE, 1997; USEPA, 1994). It also found that elevated water salinity causes pre-eclampsia, skin diseases, acute respiratory infection and diarrheal diseases. A higher risk of hypertension due to saline water exposure has been found among young adults in the coastal area of Bangladesh (Nahian et al., 2018). There are no established guidelines for salinity levels in agricultural production systems in Bangladesh (Brucet et al., 2012). Bangladesh has an expected value of drinking water salinity of 600mg/L (Akter et al., 2016; Brucet et al., 2012). The joint expert committee of WHO and FAO prescribed that nutritional sodium ingestion is 2g/day (WHO, 2003).

So far, no review has shown an overall feature of salinity intrusion in Bangladesh. The impact of salinity intrusion on livestock production, performance and growth are not well documented. The research on salinity in the agricultural sector is well known, but in the livestock sector, the scenario is different. So this review was documented to know the causes, scenarios and detection techniques of salinity intrusion and the impact of salinity intrusion on agriculture, livestock, fisheries and human health. Thus, it can contribute to the sustainable livelihood and environment for the people of Bangladesh.

II. The scenario of salinity intrusion in Bangladesh

In the middle of the nineteenth century, salinity was identified as a potential hazard to agriculture (Dagar et al., 2019). Bangladesh covers a total area of 147,570 km^2, including a coastal region of 29,000 km^2. Inshore and offshore areas cover more than 30% of cultivable land and around 50% of coastal lands face varying degrees of inundation (Haque, 2006). In addition, agricultural land utilization in the salinity-affected area is approximately 53% of the country's average (Hoque et al., 2013). Bangladesh's coastal belt comprises 19 districts, which cover 32% of the country and accommodate approximately 35 million people (Rabbani and Huq, 2011). Salinity damaged 83.3 million hectares of land in 1973, rising to 102 million hectares by 2000. Following that, 105.6 million hectares were damaged by salinity in 2009 (SRDI, 2010).

In Bangladesh, around 2.5 million hectares of low-lying coastal plains have a salinity level (SL) ranging from 0.9 to 2.1 (Haque, 2006; Iftekhar and Islam, 2004). Saltwater intrusion has a greater negative impact on this coastal area than any other region of Bangladesh. Tropical cyclones have accelerated the spread of salinity intrusion into inland water and soil (SRDI, 2010). Salinity has risen by 26% in the country during the previous 35 years (Mahmuduzzaman et al., 2014). As a result, the saline-prone coastal region had a sudden yield loss of approximately 20-40% in primary crops (vegetable, cereals, potato, legumes, oilseeds, species and fruit crops) (BCAS, 2010). Most people in coastal areas rely on agriculture to produce their food, fish and cattle. People have trouble finding enough clean water to raise cattle, fish and crops because soil and water salinity are rising (Basar, 2012). Due to the harsh climate, saline intrusion impedes crop productivity throughout the year, notably during the rabi season. Unpredictable salt levels in the water throughout Bangladesh's coastal area harm around 20 million people (Clarke et al., 2015).

The livestock sector plays a key role in food supply and food security. Livestock products (meat, milk and eggs) account for 15% and 31% of per capita calorie and protein consumption, respectively (FAOSTAT, 2020). Around 30% and 6% of global ruminant meat and milk production depend on grazing systems (Herrero et al., 2013). As a result, soil and water salinity in the coastal areas is a severe barrier to agricultural productivity and fish variety (Rahman et al., 2011).

Published with open access at journalbinet.com
EISSN: 2312-7945, ©2022 The Authors, Review paper

III. Causes of salinity intrusion

There are many causes of salinity intrusion in Bangladesh. The natural, socio-economic and political systems are the leading causes and are interlinked (Mahmuduzzaman et al., 2014). Sea level rise, cyclone, geographical location, sedimentation, storm surge and tidal surge etc., are the causes of natural salinity (Coleman, 1969; Milliman and Meade, 1983). At the same time, socio-economic causes include anthropogenic activities such as shrimp farming, weak infrastructure, poor maintenance and climatic variables such as increased GHG emission, temperature rise etc. (Flaherty et al., 2006). The political systems include weak water governance systems at the local level, cross-boundary river policy, construction of barrages by the neighbouring countries, etc. (Mahmuduzzaman et al., 2014).

However, when alluvium from the upward stream comes in contact with the seawater, it turns salty and continues to inundate at high tides and ingress seawater through streams. Tidal flooding during the rainy season (June-October), a lack of rainfall during the dry season (November-March) and the upward or lateral migration of saline subsurface water are the primary sources of salinity intrusion. Additionally, seasonal variations in rainfall, faulty irrigation or inadequate vegetable coverage in the saline areas are the additional causes of salinity intrusion (Miah et al., 2004). Salinity intrusion can also be caused by seasonal changes in rainfall, improper irrigation, or inadequate vegetable covers in saline locations. Furthermore, salty water inundating agricultural land for shrimp farming is a common route for salinity intrusion (Miah et al., 2020). There are also reports that the extraction of Ganges water at the Farakka barrage outside Bangladesh's border has reduced freshwater supply, resulting in a salt intrusion in the mainland (Mazid, 1994).

IV. Salinity chain

Salinity is a contemporary issue anticipated to worsen due to climate change and rising sea levels (Khanom, 2016). In this condition, the livelihood of agriculture is remarkably impacted, including soil and groundwater pollution, followed by health concerns and long-term environmental consequences. Due to rising salinity, there is a scarcity of grazing pasture and fodder crops for livestock production (Barnhizer and de la Torre, 2003). Bangladesh's diminished livestock production capacity has had significant economic and nutritional effects, particularly on children (Kendrick, 1994).

People have also transformed freshwater regions by introducing salty water for shrimp production, increasing salinity in the surrounding areas and causing damage to grazing areas. Changes in agrobiodiversity have resulted in lower livestock, crops and fish production in Bangladesh (Rahman et al., 2011). In Bangladesh, there are presently no specified salinity guidelines for agricultural production systems (WHO, 2004). As human livelihood is closely linked to agriculture, more significant health hazards such as hypertension are found in coastal areas than in noncoastal areas. It was hypothesized to be caused by saline water and crops. Furthermore, due to the reduced productivity of livestock and fisheries, people are suffering from economic loss and food security (Howard and Bartram, 2003).

V. Salinity level

The earth is not devoid of salts. Soluble salts are found at minute levels in all soils, rivers and rocks are a natural element of the landscape. It is only when they reach a particular proportion that a salt land is formed. Under certain conditions, these salts accumulate through salinization (Schofield et al., 2001). Since the dawn of agriculture, humans have been dealing with salinity. Although the issue has always been environmentally significant in arid and semiarid areas of the world, the adverse effects of the problem were realized only when it threatened the food and nutritional security of the population (Dagar et al., 2019). Deserts and semiarid areas are the most typical locations for saline soils, primarily under the influence of sodium chloride and sulphate. They are rarely seen in sub-humid and humid climates. Salts are also present in water, but when they exceed the normal value, it causes salinity. There are no established guidelines for salinity levels in agricultural production systems in Bangladesh (Brucet et al., 2012). Bangladesh has a standard value of drinking water salinity of 600mg/L (Akter et al., 2016; Brucet et al., 2012). The joint expert committee of WHO and FAO prescribed that nutritional sodium ingestion is 2g/day (WHO, 2003). According to salinity level, water and soil are classified and shown in Table 01 and Table 02.

Published with open access at journalbinet.com
EISSN: 2312-7945, ©2022 The Authors, Review paper

Table 01. Water type according to salt concentration

Water class	salt concentration (mg/L)	water type
Nonsaline	<500	Drinking and irrigation
Slightly saline	500-1500	Irrigation
Moderately saline	1500-7000	Primary drainage water and groundwater
Highly saline	7000-15000	Secondary drainage water and groundwater
Very highly saline	15,000-35,000	Very saline groundwater
Brine	>35,000	Seawater

*Source: Rhoades et al., 1992

Table 02. Soil type according to salt concentration

Salt concentration of the soil water (saturated extract) in g/L	Salinity
0-3	Non-saline
3-6	slightly saline
6-12	medium saline
more than 12	highly saline

*Source: FAO, 2001

VI. Detection technique

Salinity can be measured in several ways. The most common detection technique is discussed here. A soil or water sample's electrical conductivity (EC) is influenced by the concentration and composition of dissolved salts. An electric current is passed through a soil or water sample between the two electrodes of a salinity meter to calculate electrical conductivity (EC). A high EC value implies a high salinity level because salts improve a solution's ability to conduct electrical current (Slinger and Tension, 2005).

Remote sensing technology has outperformed previous methods for detecting soil salinity, providing more informative and professional methods for monitoring and mapping soil salinity. Soil salinity can be assessed using remote sensing data acquired by sensors such as direct and indirect indicators. Direct indicators are the apparent salt characteristics on the soil surface and indirect indicators are the presence of halophytic plants and measuring the performance level of salt-tolerant crops (Allbed and Kumar, 2013). Microwave Salinity Sensors have a fixed frequency of microwave transmissions. This type of sensor is based on the microwave signals' attenuation and phase. There is one transmitter probe and two receiver probes in this type of salinity sensor (Seraj and Rahmat, 2014).

Satellite image analysis aids salinity detection, monitoring and mapping. A multiple regression equation was developed using an integrated salinity index and field data method to forecast soil salinity. The correlations between several indices and soil salinity field data were calculated to determine the value. The best regression model was selected considering the high R^2 value, low P-value and low Akaike's Information Criterion. About 20% variation was observed between the field data and predicted EC from the satellite image analysis. The precision of this salinity detection technique depends on the accuracy and uniform distribution of field data (Morshed et al., 2016). Chlorinity Titration, also known as the Mohr method, involves titrating a sample of seawater with a known concentration of silver nitrate solution to the point when all halides (chloride plus a little quantity of bromide) have precipitated as silver halide (Strickland and Parsons, 1972).

VII. Impact of salinity intrusion

The impact of salinity intrusion is higher in the coastal area than in any other part of Bangladesh. It contaminates surface water and groundwater supplies, destroys wetlands and threatens people's health. Moreover, salinity intrusion has steadily expanded into inland water and soil due to tropical cyclones. As a result, it jeopardizes many people's livelihoods, especially those who rely on livestock, fisheries and agriculture (Basar, 2012; Scialabba, 1998).

Impact on Agriculture

The people of Bangladesh rely on agriculture for their livelihood. The saline intrusion, on the other hand, limits agricultural productivity and crop cultivation yearly, as most crops lose their yield capabilities. Micronutrient insufficiency in soils is caused by high soil pH (6.0-8.4) (Haque, 2006). The

Published with open access at journalbinet.com
EISSN: 2312-7945, ©2022 The Authors, Review paper

soil fertility level depends on organic matter content, but salinity decreases the level of organic matter in the soil. The organic matter content of the coastal soils is very low (1.0–1.5%). N and P nutrient deficiencies are common in saline soils (Karim et al., 1990). Furthermore, significant saline intrusion may result in zero agricultural yields, resulting in a food catastrophe (Miah, 2014). Rice (Aman/Boro) is the most important field crop in the south-west coastal region of Bangladesh. However, farmers do not cultivate rice as the salinity level increases during Aus growing season (Miah et al., 2020). Climate change-induced saline intrusion has resulted in a significant yield loss of approximately 14.05 lakh tons per year of main crops (cereals, potato, legumes, oilseeds, vegetables, species and fruits), a total yield loss of 20-40% (BCAS, 2010).

Salinity intrusion also reduces the yield of both fruit and forest trees. Mango, Betel nut, Date palm, Giant taro, Jackfruit, Blackberry, Wax jumbo and other fruit trees are rapidly disappearing (Miah et al., 2020). In agriculture, the saline intrusion significantly affects tree species production, soil fertility, disease and insect infestation in field crops and yield reduction. As for the environment, salinity intrusion greatly influences the physiographic structure of saline places (Haque, 2006). The dry season is only suitable for agricultural growth in the coastal region since soil salinity rises yearly. However, the saline intrusion is making dry-season agriculture challenging. This negatively influences crop productivity (Clarke et al., 2015). A lack of grazing pasture and food for livestock was also a result of the salinity. This impacts not just the community's livelihood but also the health and development of the children. As a result, it was predicted that the long-term effects of saline intrusion would undoubtedly collapse the food security ring (Kendrick, 1994).

Impact on livestock

The livestock sector plays an essential role for the people of Bangladesh. The survival of livestock relies on the field grass, water and dairy feed. Saline water is linked to these types of natural resources. However, the number of animals is decreased due to a lack of feed, fodder, straw and fresh drinking and irrigation water. Therefore, it harms livestock production and growth (Abdelsattar et al., 2020; Ru and Glatz, 2004). In addition, several studies have shown that animals may quit drinking water at exceptionally high mineral concentrations to prevent toxicity (Wilson, 1975; Mdletshe et al., 2017). As a result, saline water may reduce animal body weight, appetite and feed intake. Water consumption was enhanced at low salinity levels in specific trials but decreased when the amount was increased to 2% (El-sattar et al., 2020).

Animals suffer from diarrhoea, skin disorders, liver fluke, loss of body weight and immune system breakdown due to their significant reliance on salinity-affected fodder crops. Different livestock species have different levels of saltwater tolerance. Pregnant, lactating and younger cattle are more susceptible to stress than mature animals (Stoeglehner et al., 2011). Livestock that has been exposed to high salinity levels may be able to transfer illnesses to humans. As a result, salinity levels in coastal areas need to be regulated for animal production (DAP, 2016).

Impact on fisheries

As coastal salinity affects agricultural production, the people in the coastal region are sometimes driven to shift agricultural land to shrimp farms and other alternate sources of income (Rahman et al., 2011). It has a significant impact on freshwater systems. Salinity intrusion has an impact on aquatic ecosystems and the fishing industry. Native fish species in both open and freshwater sources are steadily declining due to the salinity intrusion (Brucet et al., 2012). Moreover, due to the intensity of cyclones in Bangladesh, saline water has risen along the coastal belt. In the coastal belt, freshwater bodies have closely linked to saline water. It causes changes in the trophic structure and variety of shallow freshwater bodies and enhances trophic interactions' intensity (Ziaul Islam et al., 2014). As a consequence, saline water fish are mixed with freshwater fish. As a result, the incursion of saline water into various freshwater bodies has caused the extinction of numerous fish species (DAP, 2016). The status of endangered and extinct fish species in the coastal belt is shown in Table 03.

Table 03. Status of endangered and extinct fish species in the coastal belt (Source: Alam et al., 2017)

Category	% endangered	% extinct	Causes
Inland fishes (59)	19	12	salinity
Marine fishes (57)	24	12	Cyclone/salinity
Shrimps (4)	25	25	Cyclone/salinity

Published with open access at journalbinet.com
EISSN: 2312-7945, ©2022 The Authors, Review paper

Impact on Human health

The salinity intrusion severely affects the life and livelihood of the people of Bangladesh. The people are suffering from pure drinking water, irrigation water and loss of agricultural lands (Baten et al., 2015). In addition, natural calamities like increasing sea levels, cyclones, floods and land erosion brought saline water to the surface and groundwater, resulting in severe freshwater scarcity. Salinity significantly impacts many essential aspects of human health, including food availability, freshwater availability, physical safety and the microbial environment (Tilmanand Clark, 2014).

The consumption of animals and fish becomes unsustainable as saline water combines with inland water. People are now experiencing high blood pressure, diarrhoea and cholera (Azizullah et al., 2011). People consume more salt than they require for optimum health, not just via water but also through eating food grown in these places (Patnaik, 1996). Pregnant women and children are among the most vulnerable populations. Salinity intrusion was assumed to be the higher prevalence of hypertension in pregnant women on the south-western coast of Bangladesh than in noncoastal pregnant women (Khan et al.,2011). Pregnant women are at a higher risk of (pre)eclampsia and post-partum infant morbidity and death than non-pregnant women. People develop various disorders due to their exposure to saltwater, including skin problems, hair loss, diarrhoea, gastrointestinal diseases and high blood pressure (Nahian et al., 2018).

On the other hand, females have a 31% greater likelihood of becoming hypertensive than males. Higher salt in food grains may have also contributed to increased birth abnormalities, a major issue for Bangladesh's future. Following a calamity such as a flood or a hurricane, cholera can spread like an epidemic (Khan et al., 2011). Malnutrition, undernutrition, waterborne and food-borne infections and even hunger are all influenced by a lack of drinking water and overconsumption of saline water in coastal communities (Cervero-Arago et al., 2015). The summary of the potential impacts of salinity intrusion is shown in Table 04.

Table 04. Summary of the potential impacts of salinity intrusion

Indicator	Potential implications of salinity intrusion
Feed sources	Salinity reduces soil fertility and makes it unable to grow more crops, grass, fodder and other plants. This could restrict animal access to pastures and create more significant disruptions to feed production (Miah et al., 2004). Also, humans may suffer from food insecurity (Kendrick, 1994).
Water sources	Higher salt in water greatly affects the freshwater system and makes it unable for consumption. Moreover, due to the intensity of cyclones in Bangladesh, saline water has risen along the coastal belt. In the coastal belt, freshwater bodies have closely linked to saline water. It causes changes in the trophic structure and variety of shallow freshwater bodies and enhances trophic interactions' intensity (Ziaul Islam et al., 2014).
Soil sources	Due to the increased frequency and intensity of storm surges, the sea level is rising, resulting in soil salinity. Micronutrient insufficiency in soils is caused by high soil pH (6.0-8.4) (Haque, 2006). The soil fertility level depends on organic matter content, but salinity decreases the level of organic matter in the soil. Furthermore, significant saline intrusion may result in zero agricultural yields, resulting in a food catastrophe (Miah et al., 2004).
Animal health and production	Salinity negatively influences animal output, welfare and life expectancy. The survival of animals relies on dairy feed, grass and water. Saline water is linked to these types of natural resources. However, the number of animals is decreased due to a lack of feed, fodder, straw and fresh drinking and irrigation water. Therefore, it harms livestock production and growth (Abdelsattar et al., 2020; Ru and Glatz, 2004).
Human health	Excessive salt has negative health consequences, including hypertension (high blood pressure) in both males and females, which increases the risk of stroke. Pregnant women are at a higher risk of gestational hypertension, (pre)eclampsia and post-partum infant morbidity and death than non-pregnant women (Khan et al., 2011). People suffer from various diseases due to saltwater usage, including skin problems, hair loss, diarrhoea, gastrointestinal infections and high blood pressure (Nahian et al., 2018).

Published with open access at journalbinet.com
EISSN: 2312-7945, ©2022 The Authors, Review paper

VIII. Management of salinity intrusion

Under this circumstance, salinity intrusion control is a critical concern for Bangladesh. Soil and water salinity can be reduced in a variety of ways. It includes zoning of coastal salinity areas, construction of dams and sluices, harvesting of rainwater for irrigation, application of potash fertilizer, reducing of groundwater level, a plantation program, selection of salinity tolerance cultivars, coastal embankment projects and public awareness programs all of which can help Bangladesh's people achieve its mission of sustainable livelihood (Alam et al., 2017). To boost agriculture in saline-prone areas, raise awareness about modern saline reclamation techniques such as proper soil management, fertilizer usage, increasing cultivation, Shorjan cultivation, stress-tolerant crop varieties and alternative cropping methods (Abdelsattar et al., 2020). Furthermore, encourage alternative livelihood systems such as social forestation, household agriculture and pond fishing for coastal community development. In addition, extensive research should be maintained to aid in developing alternative food security methods in saline-prone coastal locations (Khanom, 2016).

IX. Conclusion

The coastal region of Bangladesh is at extreme risk due to high soil and water salinity. The salinity intrusion hampers agricultural and livestock productivity and negatively influences the diversity of fish in the coastal area. The diminishing land, fish and animal production, with a move toward negative nutritional balance, is one of the main concerns for food security issues. Furthermore, people are suffering many health problems along with it. Salinity problem is also increasing due to ineffective policy execution, amplifying the adverse effects on food security. Therefore, it is essential to explore the possibilities for increasing agricultural production for the growing population throughout the world and the coastal region of Bangladesh. As a result, preventing land salinization is a critical issue for the country's food security and long-term land management methods are required.

X. References

[1]. Abdelsattar, M., Hussein, A., Abd El-Ati, M. N. and Saleem, A. M. (2020). Impacts of saline water stress on livestock production: A review. SVU-International Journal of Agricultural Sciences, 2(1), 1–12. https://doi.org/10.21608/svuijas.2020.67635

[2]. Ahmed, Z. U., Nuruzzaman, A. K. M., Rabbi, F. and Ahmed, S. (2017). Causes of Salinity Intrusion in Coastal Belt of Bangladesh. International Journal of Plant Research, 5(4A), 8–13. https://doi.org/10.5923/s.plant.201401.02

[3]. Ahsan, M. (2010). Saline soils of Bangladesh. Soil Resource Development Institute. Dhaka, Bangladesh.

[4]. Ahsan, M. E. (2013). Coastal Zone of Bangladesh : Fisheries Resources and its Potentials. Lap LAMBERT Academic Publishing, Germany. https://doi.org/10.13140/2.1.1253.7928

[5]. Akter, T., Jhohura, F. T., Akter, F., Chowdhury, T. R., Mistry, S. K., Dey, D. and Rahman, M. (2016). Water Quality Index for measuring drinking water quality in rural Bangladesh: A cross-sectional study. Journal of Health, Population and Nutrition, 35(1). https://doi.org/10.1186/s41043-016-0041-5

[6]. Alam, A., Sarker, N., Nasiruddin, K. and Shohael, A. (2014). Salinity stress on morphological and nutritional quality of Napier cultivars under hydroponic conditions. Bangladesh Journal of Animal Science, 46(2), 102–108.

[7]. Alam, M. Z., Carpenter-boggs, L., Mitra, S., Haque, M., Halsey, J., Rokonuzzaman, M. and Moniruzzaman, M. (2017). Effect of Salinity Intrusion on Food Crops, Livestock and Fish Species at Kalapara Coastal Belt in Bangladesh. Journal of Food Quality, 1–24.

[8]. Allbed, A. and Kumar, L. (2013). Soil Salinity Mapping and Monitoring in Arid and Semi-Arid Regions Using Remote Sensing Technology: A Review. Advances in Remote Sensing, 2(4), 373–385. https://doi.org/10.4236/ars.2013.24040

[9]. Azizullah, A., Khattak, M. N. K., Richter, P. and Häder, D. P. (2011). Water pollution in Pakistan and its impact on public health - A review. Environment International, 37, 479–497. https://doi.org/10.1016/j.envint.2010.10.007

[10]. Bangladesh Center for Advanced Studies (BCAS). (2010). Assessing long-term impacts and vulnerabilities on crop production due to climate change in coastal areas of Bangladesh. Final report 10 (08).

Published with open access at journalbinet.com
EISSN: 2312-7945, ©2022 The Authors, Review paper

[11]. Barnhizer, D. R. and de la Torre, I. (2003). The Blues of a Revolution: The Damaging Impacts of Shrimp Farming. Retrieved from https://engagedscholarship.csuohio.edu/scholbks/4/
[12]. Basar, A. (2012). Water security in coastal region of Bangladesh: would desalination be a solution to the vulnerable communities of the sundarbans? Bangladesh E-Journal of Sociology, 9(2), 31–39.
[13]. Baten, M. A., Seal, L. and Lisa, K. S. (2015). Salinity Intrusion in Interior Coast of Bangladesh: Challenges to Agriculture in South-Central Coastal Zone. American Journal of Climate Change, 4(3), 248–262. https://doi.org/10.4236/ajcc.2015.43020
[14]. Berger, L. L. and Cunha, T. J. (1993). Salt and trace minerals for livestock, poultry and other animals, 17-23. Alexandria, Va, USA: Salt Institute.
[15]. Brucet, S., Boix, D., Nathansen, L. W., Quintana, X. D., Jensen, E., Balayla, D. and Jeppesen, E. (2012). Effects of temperature, salinity and fish in structuring the macroinvertebrate community in shallow lakes: Implications for effects of climate change. PLoS ONE, 7(2). https://doi.org/10.1371/journal.pone.0030877
[16]. Cervero-Arago, S., Rodrıguez-Martınez, S., Puertas-Bennasar, A. and Araujo, R. M. (2015). Effect of common drinking water disinfectants, chlorine and heat on free Legionella and amoebae_associated Legionella. PLoS ONE, 10(8), e0134726.
[17]. Clarke, D., Williams, S., Jahiruddin, M., Parks, K. and Salehin, M. (2015). Projections of on-farm salinity in coastal Bangladesh. Environmental Science: Processes and Impacts, 17(6), 1127–1136. https://doi.org/10.1039/c4em00682h
[18]. Coleman, J. M. (1969). Brahmaputra River: Channel processes and sedimentation. Sedimentary Geology, 3(2–3), 129–239. https://doi.org/10.1016/0037-0738(69)90010-4
[19]. Dagar, J. C., Yadav, R. K., Singh, A. and Singh, N. T. (2019). Historical Perspectives and Dynamics of Nature, Extent, Classification and Management of Salt-affected Soils and Waters. In Research Developments in Saline Agriculture, Springer, Singapore, 3-52.
[20]. DAP. (2016). Government of Western Australia (Department of Agriculture and Food). Water quality for livestock.
[21]. DoE (Department of Environment). (1997). The environment conservation rules 1997, Ministry of Environment and Forest, Dhaka, Bangladesh.
[22]. El-sattar, M. M. A., Hussein, A. and Saleem, A. M. (2020). Impacts of saline water stress on livestock production: A review. SVU-International Journal of Agricultural Sciences, 2(1), 1–13. https://doi.org/10.21608/svuijas.2020.67635
[23]. FAO. (2001). Chapter 7- Salty soils. Food and Drug Administration, Rome.
[24]. FAOSTAT. (2020). Faostat. http://www.fao.org/faostat/en/
[25]. Flaherty, M., Szuster, B. and Miller, P. (2000). Low salinity inland shrimp farming in Thailand. Ambio, 29(3), 174–179. https://doi.org/10.1579/0044-7447-29.3.174
[26]. Haque, S. A. (2006). Salinity problems and crop production in coastal regions of Bangladesh. Pakistan Journal of Botany, 38, 1359–1365. Retrieved from http://www.pakbs.org/pjbot/PDFs/38(5)/PJB38(5)1359.pdf
[27]. Herrero, M., Havlík, P., Valin, H., Notenbaert, A., Rufino, M. C., Thornton, P. K. and Obersteiner, M. (2013). Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. Proceedings of the National Academy of Sciences of the United States of America, 110(52), 20888–20893. https://doi.org/10.1073/pnas.1308149110
[28]. Hoque, M. A. A., Saika, U., Sarder, B. C. and Biswas, K. K. (2013). Environmental and Socio-economic Impacts of Salinity Intrusion in the Coastal Area: A Case Study on Munshigong Union, Shymnagor, Satkhira. Jahangirnagar University Environmental Bulletin, 2, 41–49. https://doi.org/10.3329/jueb.v2i0.16329
[29]. Howard, G. and Bartram, J. (2003). Domestic Water Quantity , Service Level and Health. World Health Organization, 39. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/67884/WHO_SDE_WSH_03.02.pdf
[30]. Iftekhar, M. S. and Islam, M. R. (2004). Managing mangroves in Bangladesh: A strategy analysis. Journal of Coastal Conservation, 10(1), 139–146. https://doi.org/10.1652/1400-0350(2004)010[0139:MMIBAS]2.0.CO;2
[31]. Irfan, M. and Hayat, S. (2011). Causes of salinity and plant manifestations to salt stress : A review. Environmental Biology, 32, 667–685.
[32]. Karim, Z., Hussain, S. G. and Ahmed, M. (1990). Salinity problems and crop intensification in the coastal regions of Bangladesh. Bangladesh Agricultural Research Council. Retrieved from http://180.211.164.227/handle/123456789/190

Published with open access at journalbinet.com
EISSN: 2312-7945, ©2022 The Authors, Review paper

[33]. Kendrick, A. (1994). The Gher Revolution: The Social Impacts of Technological Change in Freshwater Prawn Cultivation in Southern Bangladesh. In The Report of a Social Impact Assessment prepared for CARE International Bangladesh with support from the Bangladesh Aquaculture and Fisheries Resources Unit (BAFRU). Retrieved from https://ci.nii.ac.jp/naid/10020015282/

[34]. Khan, A. E, Ireson, A., Kovats, S., Mojumder, S. K., Khusru, A., Rahman, A. and Vineis, P. (2011). Drinking water salinity and maternal health in coastal Bangladesh: implications of climate change. Environmental Health Perspectives, 119(9), 1328–1332.

[35]. Khan, Aneire Ehmar, Ireson, A., Kovats, S., Mojumder, S. K., Khusru, A., Rahman, A. and Vineis, P. (2011). Drinking water salinity and maternal health in coastal Bangladesh: Implications of climate change. Environmental Health Perspectives, 119(9), 1328–1332. https://doi.org/10.1289/ehp.1002804

[36]. Khanom, T. (2016). Effect of salinity on food security in the context of interior coast of Bangladesh. Ocean and Coastal Management, 130, 205–212. https://doi.org/10.1016/j.ocecoaman.2016.06.013

[37]. Mahmuduzzaman, M., Ahmed, Z. U., Nuruzzaman, A. K. M. and Ahmed, F. R. S. (2014). Causes of Salinity Intrusion in Coastal Belt of Bangladesh. International Journal of Plant Research, 4(4A), 8–13.

[38]. Mazid, M. A. (1994). Status and potential of shrimp farming in Khulna region. In Proceeding of the National Seminar on Integrated Management of Ganges Flood Plains and Sundarbans Ecosystem, Khulna University, 133.

[39]. Mdletshe, Z. M., Chimonyo, M., Marufu, M. C. and Nsahlai, I. V. (2017). Effects of saline water consumption on physiological responses in Nguni goats. Small Ruminant Research, 153, 209–211. https://doi.org/10.1016/J.SMALLRUMRES.2017.06.019

[40]. Miah, M. Y., Mannan, M. A., Quddus, K. G., Mahmud, M. A. M. and Baida, T. (2004). Salinity on Cultivable Land and Its Effects on Crops. Pakistan Journal of Biological Sciences, 7(8), 1322–1326. https://doi.org/10.3923/pjbs.2004.1322.1326

[41]. Miah, Md Yunus, Zia, M., Kamal, U., Salam, M. A. and Islam, M. S. (2020). Impact of salinity intrusion on agriculture of Southwest Bangladesh-A review. International Journal of Agricultural Policy and Research, 8(2), 40–47. https://doi.org/10.15739/IJAPR.20.005

[42]. Milliman, J. D. and Meade, R. H. (1983). Worldwide delivery of sediment to the oceans. Journal of Geology, 91(1), 1–21. https://doi.org/10.1086/628741

[43]. Morshed, M. M., Islam, M. T. and Jamil, R. (2016). Soil salinity detection from satellite image analysis: an integrated approach of salinity indices and field data. Environmental Monitoring and Assessment, 188(2), 1–10. https://doi.org/10.1007/s10661-015-5045-x

[44]. Nahian, M. A., Ahmed, A., Lázár, A. N., Hutton, C. W., Salehin, M. and Streatfield, P. K. (2018). Drinking water salinity associated health crisis in coastal Bangladesh. Elementa: Science of the anthropocene, 6. https://doi.org/10.1525/elementa.143

[45]. Patnaik, U. (1996). Export-Oriented Agriculture and Food Security in Developing Countries and India. Economic and Political Weekly, 31(35/37), 2429–2449. Retrieved from https://www.jstor.org/stable/4404563

[46]. Rabbani, G. and Huq, S. (2011). Adaptation technologies in agriculture: The economics of rice-farming technology in climate-vulnerable areas of Bangladesh. In Technologies for Adaptation-Perspectives and Practical Experiences. Retrieved from https://www.osti.gov/etdeweb/servlets/purl/1031198#page=115

[47]. Rahman, M. H., Lund, T. and Bryceson, I. (2011). Salinity effects on food habits in three coastal, rural villages in Bangladesh. Renewable Agriculture and Food Systems, 26(3), 230–242. https://doi.org/10.1017/S1742170511000020

[48]. Rhoades, J. D., Kandiah, A. and Mashali, A. M. (1992). The use of saline waters for crop production-FAO irrigation and drainage paper 48. FAO, Rome, 133.

[49]. Ru, Y. and Glatz, P. C. (2004). Effect of Salt Intake on Feed Intake and Growth Rate of Fallow and Red Weaner Deer. A Report for the Rural Industries Research and Development Corporation. Rural Industries Research and Development Corporation.

[50]. Schofield, R., Thomas, D. S. and Kirkby, M. J. (2001). Causal processes of soil salinization in Tunisia, Spain and Hungary. Land Degradation and Development, 12(2), 163-181.

[51]. Scialabba, N. (Ed.). (1998). Integrated coastal area management and agriculture, forestry and fisheries. Food & Agriculture Org, Roma (Italia).

Published with open access at journalbinet.com
EISSN: 2312-7945, ©2022 The Authors, Review paper

[52]. Seraj, H. and Rahmat, M. F. ad. (2014). Review of water salinity measurement methods and considering salinity in measuring water area phase fraction of wet gas. Sensors and Transducers, 162(1), 208–214.
[53]. Shammi, M., Rahman, M. and Bondad, S. E. (2019). Impacts of Salinity Intrusion in Community Health : A Review of Experiences on Drinking Water Sodium from Coastal Areas of Bangladesh. Healthcare, 7(50), 1–19. https://doi.org/10.3390/healthcare7010050
[54]. Slinger, D. and Tension, K. (2005). Salinity Glove Box Guide: NSW Murray & Murrumbidgee catchments, NSW Department of Primary Industrie, Wagga Wagga, NSW.
[55]. Soil Resources Development Institute (SRDI). (2010). Saline Soils of Bangladesh; SRDI, Ministry of Agriculture, Dhaka, Bangladesh.
[56]. Stoeglehner, G., Edwards, P., Daniels, P. and Narodoslawsky, M. (2011). The water supply footprint (WSF): A strategic planning tool for sustainable regional and local water supplies. Journal of Cleaner Production, 19(15), 1677–1686. https://doi.org/10.1016/j.jclepro.2011.05.020
[57]. Strickland, J. D. H. and Parsons, T. R. (1972). A practical handbook of seawater analysis. The Alger Press Ltd, Ottawa, Canada.
[58]. Tilman, D. and Clark, M. (2014). Global diets link environmental sustainability and human health. Nature, 515(7528), 518–522. https://doi.org/10.1038/nature13959
[59]. USEPA (United States Environmental Protection Agency). (1994). Water-quality criteria, standards, or recommended limits for selected properties and constituents. Hydrology of the black hills area, South Dakota. 46-49.
[60]. Vineis, P., Chan, Q. and Khan, A. (2011). Climate change impacts on water salinity and health. Journal of Epidemiology and Global Health, 1(1), 5–10. https://doi.org/10.1016/j.jegh.2011.09.001
[61]. WHO. (2003). Diet, nutrition and the prevention of chronic diseases. World Health Organization Technical Report Series, 916. Retrieved from http://health.euroafrica.org/books/dietnutritionwho.pdf
[62]. Wilson, A. D. (1975). Influence of water salinity on sheep performance while grazing on natural grassland and saltbush pastures. Australian Journal of Experimental Agriculture, 15(77), 760–765. https://doi.org/10.1071/EA9750760
[63]. World Health Organization, Water, Sanitation and Health Team (2004). Guidelines for drinking-water quality. Vol. 1, Recommendations, 3rd ed. World Health Organization. https://apps.who.int/iris/handle/10665/42852
[64]. Ziaul Islam, K., Sirajul Islam, M., O. Lacoursière, J. and Dessborn, L. (2014). Low Cost Rainwater Harvesting: An Alternate Solution to Salinity Affected Coastal Region of Bangladesh. American Journal of Water Resources, 2(6), 141–148. https://doi.org/10.12691/ajwr-2-6-2.

HOW TO CITE THIS ARTICLE?

Crossref: https://doi.org/10.18801/jbar.290122.293

MLA
Islam, P. et al. "Salinity: A chain to be assessed". Journal of Bioscience and Agriculture Research, 29(01), (2022): 2416-2425.

APA
Islam, P., Khatun, P. and Islam, A. (2022). Salinity: A chain to be assessed. *Journal of Bioscience and Agriculture Research*, 29(01), 2416-2425.

Chicago
Islam, P., Khatun, P. and Islam, A. "Salinity: A chain to be assessed". Journal of Bioscience and Agriculture Research, 29(01), (2022): 2416-2425.

Harvard
Islam, P., Khatun, P. and Islam, A. 2022. Salinity: A chain to be assessed. Journal of Bioscience and Agriculture Research, 29(01), pp. 2416-2425.

Vancouver
Islam, P, Khatun, P and Islam, A. Salinity: A chain to be assessed. Journal of Bioscience and Agriculture Research, 2022 July, 29(01): 2416-2425.

Published with open access at journalbinet.com
EISSN: 2312-7945, ©2022 The Authors, Review paper