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Original article

Impact of drinking of saline water on hemato-biochemical parameters of Black Bengal goats in the selected areas of Bangladesh

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ABSTRACT

Global climatic changes are contaminating ground and surface water sources around the world, resulting in increased salinity. Knowing the animals' typical physiological capability for salinity tolerance without compromising their health is a necessity. The research was undertaken to determine the impacts of drinking water salinity on hemato-biochemical parameters of Black Bengal goats. A total of 40 Black Bengal goats (20 male and 20 female), age ranging from 1 to 5 years, were randomly selected and divided into 2 groups. The animals of group 1 received higher saline water (12 ppt) and those in group 2 received lower saline water (1 ppt) as regular drinking water. Blood parameters of all selected goats were measured. Serum creatinine, uric acid, urea, potassium, sodium, and chloride were significantly higher ($P< 0.05$) in the animals of group 1 compared with group 2, although serum phosphorous was significantly lower ($P < 0.05$) in group 1 compared with group 2. There were no significant differences in serum aspartate aminotransferase (AST), alanine aminotransferase (ALT), glucose, magnesium, and calcium between the animals of group 1 and 2. AST and magnesium differed significantly ($P < 0.05$) between young and adult goats in group 1. Glucose and urea levels were slightly higher ($P < 0.05$) in young goats. In both groups, male goats had significantly higher ($P < 0.05$) serum potassium and urea levels than female goats. The results suggest that Black Bengal goats of the coastal areas have different salt tolerance capacities based on their age and sex, and adapt to higher salinity by changing kidney functions.

1. Introduction

Bangladesh remains in the front line to face the disastrous consequences of the global warming process. During the last two decades, the world's sea level rose at a rate of 3.1 mm per year on average (Cruz et al., 2007). As a consequence, large arable land in the southern coastal belt of the country has remained submerged under the saline water (Haque, 2006), thus creates emerging threats to coastal animals' health and production (Hallegatte et al., 2013).

Drinking water is an important nutrient for humans, animals, and plants, and the quantity and quality of drinking water have a major effect on animal efficiency. It is known that salt (NaCl) is an important element in animal diets that plays a dominant role in regulating the homeostasis of body fluid, nerve function, maintenance of body temperature, glucose and water absorption (Suttle, 2010). However, excessive and long-term saline drinking water consumption can cause serious health problems such as impaired cellular osmosis, hypertension leading to renal and cardiovascular diseases and decreased production (He and MacGregor, 2007). Earlier studies have also shown differing salt intake sensitivity depending on the source of intake, with higher food salt tolerance than drinking water, suggesting that different physiological responses are involved (Mdletshe et al., 2017).

The amount of sodium chloride in surface water in the southern coastal belt of Bangladesh is currently assumed to be more than 2%. The effects of this increased salinity on livestock farming in Bangladesh have not been thoroughly investigated till now. For the assessment of the normal physiological state of the animal, hematological and biochemical values are very important. However, literature pertaining to the impact of saline drinking water on the hemato-biochemical parameters of indigenous Black Bengal goats is scanty. Therefore, this study was undertaken to investigate the impacts of drinking water salinity on hemato-biochemical param-

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eters of Black Bengal goats. In particular, we aimed to determine the changes of blood electrolytes, liver and kidney functions of Black Bengal goats after prolonged consumption of saline drinking water and to compare the capacities of salt tolerance in male and female goats towards saline water intake.

2. Materials and methods

Procedures performed in this study were approved by the Animal Welfare and Experimentation Ethics Committee (AWEEC) of Bangladesh Agricultural University, Mymensingh-2202 [AWEEC/BAU/2021(14)].

2.1. Study area

The experiment was conducted in Koyra Upazilla of Khulna district (coastal belt) and Sharishabari Upazilla of Jamalpur district (river basin) of Bangladesh. During the study, the average temperature and humidity in Koyra and Sharishabari upazilla were 30.45 °C (minimum 18.52 °C to maximum 25.76 °C), 37% and 30.10 °C (minimum 21.53 °C to maximum 36.6 °C), 51%, respectively.

2.2. Experimental animals

A total of 40 Black Bengal goats of both sexes (20 males and 20 females) with an average body weight of 18 kg and age ranged from 1 to 5 years were randomly selected from the study area for this experiment. Group 1 comprised of 20 goats (10 males and 10 females), selected from Koyra Upazilla of Khulna district which is situated in the coastal belt of Bay of Bengal and having higher water salinity. Group 2 consisted of 20 goats (10 males and 10 females), randomly selected from Sharishabari Upazilla of Jamalpur district which is the river basin of Jamuna river and having moderate water salinity. The experimental animals were again classified as young (<2 years; $N = 13$) and adult (older than 2 years; $N = 7$) to investigate the effects of drinking water salinity on age.

2.3. Collection and processing of serum

The blood samples were collected from the jugular vein by inserting a19G needle attached to a 10 ml disposable syringe. The blood was transferred to a serum collection tube immediately after collection. The tubes were labeled and placed into icebox containing an ice bag for cooling and transferred to the laboratory for further processing. The blood sample was centrifuged (DSC-200-A2, Table Top Centrifuge, Digisystem Laboratory Instruments Inc., Taiwan) for 15 min at 3000 rpm in room temperature. The supernatant serum samples were pipette into labeled Eppendorf tube and stored at −20 °C until further analysis.

2.4. Laboratory analysis of serum

The blood electrolytes and other biochemical parameters were measured at Mohammad Hossain Central Laboratory, Bangladesh Agricultural University, Mymensingh. Glucose, urea, uric acid, ALT (alanine aminotransferase) and AST (aspartate aminotransferase) were determined by UV Spectrometer (T80, USA) using Reactivos GPL (Barcelona, Spain). Phosphorous and creatinine were measured by UV Spectrometer (T80, USA) using Vitro Scient (Egypt) and Linear (Barcelona, Spain), respectively. Magnesium was also measured using Chema Diagnostica (Italy).

2.5. Collection and analysis of water and feed samples

Drinking water samples from river and tube-well, as well as feed samples of selected study areas, were collected randomly. The NaCl concentration of drinking water was measured using a sodium chloride refractometer (HI96822 Seawater Refractometer, HANNA instruments). The pH of collected water samples was also measured by pH meter (HI2211 pH/ORP Meter, HANNA instruments).

To determine percentages of crude protein, UDK 129 Distillation Unit (Velp Scientica, Italy) and Digestion Units consist of SMS scrubber (Velp Scientifica, Italy), DK Heating Digester (Velp Scientifica, Italy) and JP Recirculating Water Aspirator (Velp Scientifica, Italy) were used. To determine Ash percentage, Muffle Furnaces (Thermolyne) was used. For crude fat percentages, Solvent Extractors (ER 148 Series, Velp Scientifica, Italy) and for fibre, AM4 Multiple Heating Stirrer (Velp Scientifica, Italy) was used. Spectrophotometric method using T60U UV/Vis Spectrophotometer (PG Instruments, UK) was used to determine sulfur and phosphorous. For the determination of sodium and potassium, a flame emission spectrophotometric method using a Flame photometer (Jenway, UK) was used. EDTA complexometric titration method was used for the determination of calcium and magnesium, and the percentage acid base titration method using Burette was applied for the determination of bicarbonate.

2.6. Statistical analysis

The data obtained in the present investigation were analyzed with SPSS version 2 software. Independent samples *t*-test (unpaired and parametric) was performed to determine the significant difference between the two groups in each parameter. For all traits, the fixed effects of age and sex in both groups were also analyzed using Independent samples *t*-test. Values of Levene's test for equality of variances were considered as significant. All data were presented as Mean ± SEM. Probability $P < 0.05$ or less were considered statistically significant.

3. Results

3.1. Composition of water and feed samples

The salinity and p^H of collected water samples at different study areas presented on Table 1. The chemical and mineral composition of feed and water samples collected from Koyra, Khulna and Sharisabari, Jamalpur districts summarized on Table 2 and 3, respectively.

3.2. Changes in liver functions

The serum aspartate aminotransferase (AST) and alanine aminotransferase (ALT) did not differ significantly ($P > 0.05$) between the two groups. However, the values were comparatively higher in group 1 than group 2 (Fig. 1). The changes of AST and ALT values did not differ significantly ($P > 0.05$) between the young and

Table 1
Salinity and p^H test of water at different areas.

Place	Source	Salinity (ppt)	pH
Koyra, Khulna	River	12	8.22
	Tube well	2	8.33
Jamalpur, Sharishabari	River and Tube well	1	8.03

Table 2
Chemical composition of feed samples collected from Koyra, Khulna and Sharisabari, Jamalpur.

Parameters	Koyra, Khulna	Sharisabari, Jamalpur
Crude protein (%)	9.53	4.63
Fibre (%)	31.55	30.53
Crude fat (%)	2.86	6.17
Ash (%)	16.11	13.22
Moisture%	18.24	13.18
Carbohydrate (%)	21.71	32.27
Calcium (%)	0.52	0.96
Mgnesium (%)	0.32	0.56
Phosphorus (%)	0.21	0.30
Sodium (mg/L)	60.92	133.74
Potasium (mg/L)	7.02	4.10

Table 3
Mineral components of drinking water samples collected from Koyra, Khulna and Sharisabari, Jamalpur.

Components (mg/L)	Koyra Khulna (River water)	Koyra Khulna (Tubewell water)	Sharisabari, Jamalpur (River and Tubewell water)
Calcium (Ca)	240.480	44.088	112.224
Magnesium (Mg)	418.046	38.888	21.388
Phosphorus (P)	0.022	0.324	1.404
Sulpher (S)	239.452	166.164	4.288
Bicarbonate (HCO^{3-})	195.2	439.2	366.0
Sodium (Na)	583.155	360.318	18.311
Potasium (K)	44.208	84.259	190.502
Chlorine (Cl)	6298.047	361.888	11.996

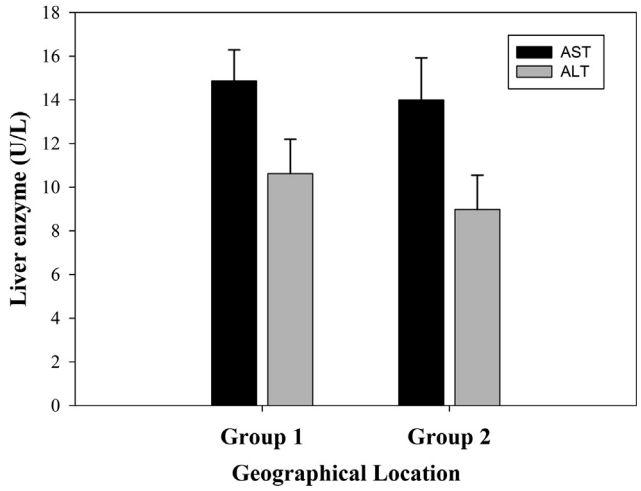

Fig. 1. Changes of liver enzymes [Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT)] in group 1 and group 2.

old, and also between the male and female animals in both the groups (Table 4 and 5).

3.3. Changes in kidney functions

The changes in serum creatinine, uric acid and urea significantly ($P < 0.01$) varied between the two groups. In group 1, all values were much higher than that of group 2 (Figs. 2 and 3). Uric acid and urea were significantly ($P < 0.05$) higher in young than adult goats in group 1 and group 2, respectively (Table 4). The changes in serum urea was significantly differed ($P < 0.01$) between female and male goats in group 2. In both groups 1 and 2, female goats had lower urea in serum compare to male goats (Table 5).

3.4. Blood electrolytes

Potassium, sodium and chloride in serum were significantly ($P < 0.05$) higher in group 1 than group 2, whereas serum phosphorous was significantly ($P < 0.05$) lower in group 1 compared to group 2 (Table 6). No significant difference was found in serum glucose, magnesium and calcium between the two groups.

In group 1, only magnesium, sodium and chloride were significantly varying ($P < 0.05$) between young and adult goats. However, in group 2, when compared between two age groups, no significant difference was found in all serum electrolytes except glucose. Glucose was significantly higher in young goats than adult goats (Table 4). Serum potassium level was significantly ($P < 0.05$) higher in male than female goats in group 1 (Table 5). All other blood electrolytes did not differ significantly between male and female goats in both group 1 and group 2 (Table 5).

4. Discussion

To measure the normal function of the liver, aspartate amino transferase (AST) and alanine amino transferase (ALT) tests are required. In those with liver cirrhosis and liver damage, AST and ALT are particularly markedly elevated (Gowda et al., 2009). In group 1, where the goats had free access to drinking salt water (12 ppt), the AST and ALT values were relatively higher. The values did not, however, exceed the reference range (Omidi-Mirzaei et al., 2018). When comparing normal drinking water, moderate saline drinking water (0.5%) and high saline drinking water (0.9%), Ghanem et al. (2018) found the same result in Barki sheep. Similarly, the salinity (1.35–1.45%) of drinking water had a substantial impact on AST and ALT in sheep and camels (Assad and El-Sherif, 2002). On the contrary, both enzymes remained unchanged although goats became steadily accustomed to raising saline water (0.25–1.5%) (Runa et al., 2020). The changes in AST and ALT between young and older goats and male and female goats did not vary significantly in the current study. No report is available to support our findings.

Glomerular filtration excretes creatinine, which is a by-product of muscle metabolism. As a result, creatinine is a reliable predictor of renal activity (Washington and Van Hoosier, 2012). In group 1, when a higher concentration of saline water (1.2%) drunk by the goats for a longer period, serum creatinine levels were higher and remained above the upper limit of the reference range (Jackson and Cockcroft, 2002), suggesting that prolonged intake of saline water had adverse effects on renal function. Similarly, Ghanem et al., (2018) reported that drinking saline water (0.5–0.9%) substantially increased creatinine levels in Barki sheep. When goats were given the option of fresh or saline water again in the sensitivity re-test phase of the experiment, Runa et al., (2020) found the highest concentration of serum creatinine. Following a saltwater ingestion process, Zoidis and Hadjigeorgiou (2017) reported that plasma creatinine concentrations were highest in the fresh water phase (up to 2% salt). Changes in the glomerular filtration rate (GFR) may explain this finding. GFR was found to be significantly higher in goats given higher salt concentrations, indicating that waste products such as urea, uric acid, and creatinine were filtered more thoroughly in the kidneys (Meintjes and Engelbrecht, 2004).

Serum urea concentrations in the animals of group 1 were found higher than the reference values (Omidi et al., 2018). Elevated urea production, decreased urea elimination, or a combination of the two can produce increased plasma/serum urea (Higgins, 2016). The greatest amounts of urea seen in this study could be attributable to reduced urinary clearance of urea due to severe renal impairment and a corresponding substantial drop in

Table 4
Changes of different blood parameters in young and adult goats in both group 1 and group 2 (Mean ± SEM).

Parameters	Group 1			Group 2		
	Young	Adult	*P* value	Young	Adult	*P* value
Aspartate aminotransferase (U/L)	13.83 ± 1.87	17.30 ± 1.27	0.29	16.43 ± 2.32	10.36 ± 2.68	0.13
Alanine transaminase (U/L)	10.92 ± 1.92	9.92 ± 3.31	0.79	10.50 ± 2.15	6.71 ± 2.06	0.26
Creatinine (mg/dl)	1.40 ± 0.04	1.30 ± 0.15	0.40	0.73 ± 0.67	0.93 ± 0.30	0.45
Uric acid (mg/dl)	4.01 ± 0.13	3.23 ± 0.19	0.01	3.09 ± 0.11	3.15 ± 0.14	0.74
Urea (mg/dl)	57.76 ± 0.67	53.83 ± 5.98	0.32	51.90 ± 1.81	45.69 ± 1.89	0.05
Glucose (mg/dl)	72.68 ± 8.59	66.17 ± 5.24	0.65	73.17 ± 7.24	50.39 ± 4.52	0.04
Magnesium (mEq/L)	2.04 ± 0.02	1.95 ± 0.01	0.04	2.00 ± 0.02	2.05 ± 0.04	0.23
Phosphorous (mg/dl)	4.76 ± 0.44	3.76 ± 0.04	0.19	5.96 ± 0.55	5.36 ± 0.70	0.52
Calcium (mg/dl)	10.57 ± 0.59	9.50 ± 0.50	0.31	11.08 ± 1.02	9.09 ± 1.31	0.26
Potassium (mmol/L)	6.21 ± 0.26	5.26 ± 0.24	0.06	5.03 ± 0.08	4.89 ± 0.15	0.41
Sodium (mmol/L)	167.61 ± 11.40	138.93 ± 2.28	0.04	135.67 ± 2.64	139.22 ± 9.95	0.75
Chloride (mmol/L)	120.58 ± 6.27	101.13 ± 1.67	0.02	100.57 ± 2.03	103.87 ± 6.22	0.64

Table 5
Different blood parameters between male and female goats in group 1 and group 2 (Mean ± SEM).

Parameters	Group 1			Group 2		
	Female	Male	*P* value	Female	Male	*P* value
Aspartate aminotransferase (U/L)	16.91 ± 1.54	12.83 ± 2.16	0.16	12.95 ± 3.32	15.05 ± 2.28	0.62
Alanine transaminase (U/L)	9.92 ± 2.63	11.31 ± 1.20	0.68	7.58 ± 1.82	10.38 ± 2.62	0.41
Creatinine (mg/dl)	1.35 ± 0.10	1.38 ± 0.04	0.76	0.88 ± 0.24	0.75 ± 0.08	0.63
Uric acid (mg/dl)	3.75 ± 0.28	3.80 ± 0.18	0.90	3.14 ± 0.11	3.09 ± 0.14	0.75
Urea (mg/dl)	55.05 ± 3.30	58.11 ± 1.11	0.41	45.30 ± 1.51	53.53 ± 0.95	0.002
Glucose(mg/dl)	59.49 ± 2.40	81.98 ± 9.94	0.08	55.36 ± 6.08	72.76 ± 8.85	0.14
Magnesium (mEq/L)	2.00 ± 0.03	2.02 ± 0.03	0.79	2.03 ± 0.03	2.01 ± 0.02	0.63
Phosphorous (mg/dl)	3.82 ± 0.12	5.10 ± 0.54	0.05	5.10 ± 0.60	6.35 ± 0.47	0.14
Calcium (mg/dl)	10.20 ± 0.68	10.30 ± 0.68	0.92	9.75 ± 1.21	10.82 ± 1.21	0.55
Potassium (mmol/L)	5.44 ± 0.18	6.41 ± 0.33	0.03	4.98 ± 0.14	4.96 ± 0.06	0.90
Sodium (mmol/L)	151.66 ± 12.85	166.36 ± 12.99	0.44	140.28 ± 7.79	133.90 ± 2.40	0.47
Chloride (mmol/L)	110.30 ± 8.21	119.20 ± 6.77	0.42	104.04 ± 4.82	99.74 ± 2.27	0.44

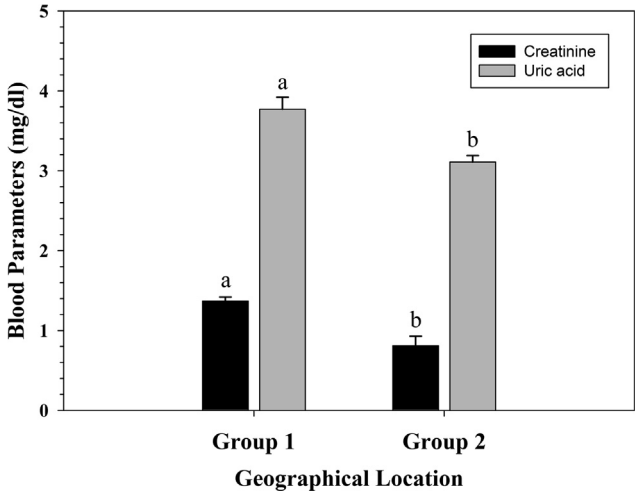

Fig. 2. Changes of serum creatinine and uric acid concentration in group 1 and group 2.

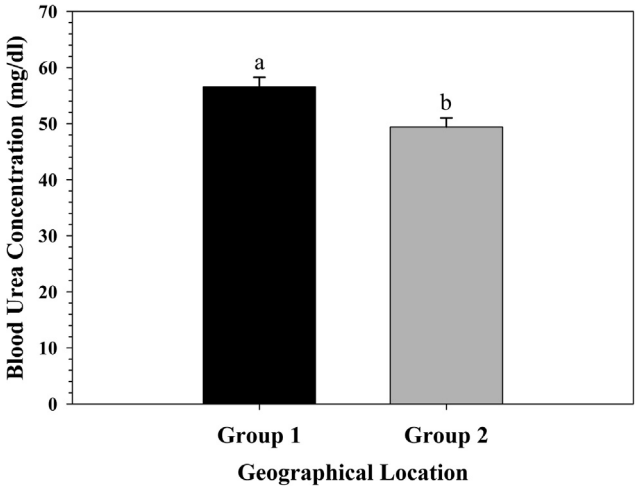

Fig. 3. Changes of serum urea concentration in group 1 and group 2.

GFR. Higher urea production could imply a high protein intake by the feed, which is linked to higher urea production and, as a result, higher serum urea concentrations (Higgins, 2016). The differences in serum urea concentrations between young and older goats may be due to the animals' ageing (Higgins, 2016).

After prolonged ingestion of saline water, significant changes in serum sodium and chloride concentrations were observed. The sodium and chloride values in group 1 were higher than the range, based on higher reference values of 156 mmol/l and 110 mmol/l given by Jackson and Cockcroft (2002) for goats. Goats, sheep (Tomas et al., 1973), and heifers (Weeth et al., 1960) receiving saline water with more than 1.3% salt showed an increase in serum sodium concentration. In contrast, serum sodium concentration was consistent with other studies in deer (Ru et al., 2005), sheep (Potter, 1968) and heifers (Weeth et al., 1960) exposed to 1–1.3% saline drinking water. Due to a lack of freshwater sources in group 1, the goats were forced to drink saline water, which resulted in higher serum sodium and chloride concentrations or decreased serum output through urine or feces.

The findings of this study revealed an increase in blood potassium concentration in goats when exposed to saline water are consistent with earlier in sheep (Potter, 1968) and cattle (Weeth et al., 1960). However, increasing the NaCl concentration in drinking

Table 6
Different blood electrolytes in group 1 and group 2 (Mean ± SEM).

Parameters	Group 1	Group 2	*P* value	Reference Range
Magnesium (mEq/L)	2.02 ± 0.02	2.02 ± 0.02	0.888	0.02–4.3[1]
Phosphorous (mg/dl)	4.46 ± 0.34	5.72 ± 0.42	0.030	4.0–11.2[2]
Calcium (mg/dl)	10.25 ± 0.45	10.29 ± 0.83	0.968	9.2–11.6[2]
Potassium (mmol/L)	5.93 ± 0.24	4.98 ± 0.74	0.003	3.4–6.1[2]
Sodium (mmol/L)	159.01 ± 8.95	137.09 ± 3.98	0.044	135–156[2]
Chloride (mmol/L)	114.75 ± 5.23	101.89 ± 2.61	0.046	98–110[2]

[1] Omidi et al. (2018).
[2] Jackson and Cockcroft (2002).

water had no effect on plasma K in goats (Zoidis and Hadjigeorgiou, 2017), but higher NaCl levels were associated with increased potassium concentrations in the urine. There were no significant changes in serum glucose, magnesium and calcium in this study which is in agreement with previous studies in goats (Runa et al., 2019) and sheep (Assad and El-Sherif, 2002).

Changes in hemato-biochemical parameters were observed in young and older goats, as well as male and female goats, suggesting that goats have different tolerance capacities for increased drinking water salinity depending on their sex and age. Younger animals were found to be more sensitive and less resistant to elevated salinity concentration than older animals (Runa et al., 2019; Wilson and Dudzinski, 1973). As a result, younger animals' adaptation to saltwater must be done with greater care in order to prevent health issues. The increased susceptibility to excess sodium can be explained by the fact that growing animals have a higher percentage of body water than adults (Riek and Gerken, 2010), which can increase Na^+ transport to cell tissues, potentially causing damage.

5. Conclusions

The results of this study suggest that long-term intake of saline water has some effects on the hemato-biochemical parameters of goats. The Black Bengal goats of the coastal areas of Bangladesh have different salt tolerance capacities based on their age and sex, and to adapt to higher salinity by changing their kidney functions. However, the effects of long-term saline water ingestion on the health of other ruminants cannot be ruled out and require further research. Additional physiological and behavioral parameters related to saltwater regulation, such as respiration rate, heart rate, and blood hormones, should be determined. Comparative studies of the health status and adaptation capacities of ruminants and monogastric animals reared in a free-range housing system in the coastal areas of Bangladesh will be particularly interesting.

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CRediT authorship contribution statement

Rukhsana A. Runa: Conceptualization, Methodology, Supervision. **Shahrier Maksud:** Methodology. **Mohammad S. Rahman:** . **Moinul Hasan:** . **Mohammad R. Alam:** Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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