# Hydro-Chemical Characterization and Irrigation Quality Assessment of Groundwater in the Mubarakganj Sugar Mills Area, Kaliganj, Jhenaidaha

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## Introduction

Groundwater has become the major source of water use in the agricultural sector in many countries where river and drainage systems are not sufficient. Therefore, poor groundwater quality for irrigation purpose is a matter of worry in recent years.[1] Under or over chemical fertilization as well as rapid urbanization and industrialization is resulting in groundwater pollution. The concentration of chemical constituents which is greatly influenced by geological formations and anthropogenic activities determine the groundwater quality.[2]
Mubarakganj Sugar Mill is one of the major sugar mills in Bangladesh which has 42000 acre of cultivable land inside. So, to have better harvest the quality maintenance of irrigation water is very essential.

## Objective

The main purpose is to identify and characterize the quality of groundwater in Mubarakganj Sugar Mills area, Jhenaidaha by distinctive groundwater qualities as regards agricultural use, based on the hydro-chemical characterization of groundwater by assessing agricultural parameters.

## Study Area

Mubarakganj sugar mills is situated in Kaliganj, Jhenadah, sited at 23°23′ N and 89°08′ E (Figure-1). It is a sugar refining mill where sugarcane is the main raw material. This sugar mill was established in 1965 and its annual production is around 12500 tons of sugar.

## Materials and Methods

The depths of selected tube wells were varying from 20 to 60 m. A total of 11 groundwater samples has been collected from different places of Mubarakganj Sugar Mills and its outlying sites and physico-chemical properties of the samples have been measured. The parameter like pH, EC, TDS and Turbidity were instantly measured by portable pH meter (SD 300 pH), EC meter (SD 320 Con) and Turbidity meter (TURB 350 IR, WTW) respectively. Flame Atomic Absorption Spectrophotometer (Shimadzu AA6800) was used to determine the concentration of Na, K, Ca and Mg in water samples after successive acid digestion and UV-Visible Spectrophotometer (Shimadzu UV2401) were used to assess the concentration of $SO_4^{2-}$ and $NO_3^-$ present in the samples. $Cl^-$ and $HCO_3^-$ were estimated by standard titrimetric method.

To assess the suitability of groundwater for irrigation uses, the following irrigational quality parameters were computed. [2,3,4,5]

$$SAR = Na^+/\sqrt{[(Ca^{2+} + Mg^{2+})/2]}$$

$$SSP \text{ (or \%Na)} = (Na^+ + K^+) \times 100/(Na^+ + K^+ + Ca^{2+} + Mg^{2+})$$

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

$$PS = Cl^- + (0.5 \times SO_4^{2-})$$

$$KR = Na^+/(Ca^{2+} + Mg^{2+})$$

$$PI = [(Na^+ + \sqrt{HCO_3^-}) \times 100]/(Na^+ + Ca^{2+} + Mg^{2+})$$

$$MH = (Mg^{2+} \times 100)/(Ca^{2+} + Mg^{2+})$$

$$CAI\text{-}I = [Cl^- - (Na^+ + K^+)]/Cl^-$$

$$CAI\text{-}II = [Cl^- - (Na^+ + K^+)]/(SO_4^{2-} + CO_3^{2-} + HCO_3^- + NO_3^-)$$

$$TH = 2.5 \times Ca^{2+} + 4.1 \times Mg^{2+}$$

$$r1 = (Na^+ - Cl^-)/SO_4^{2-}$$

$$r2 = [(Na^+ + K^+) - Cl^-]/SO_4^{2-}$$


Figure 1: Study area in Google Earth image (enclosed by purple line)

## Results and Discussion

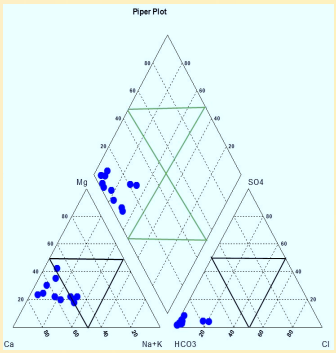


Figure (a)

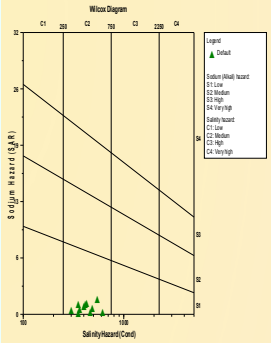


Figure (b)

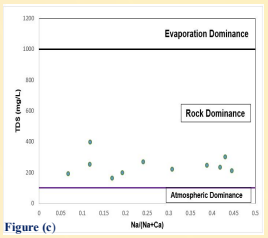


Figure (c)

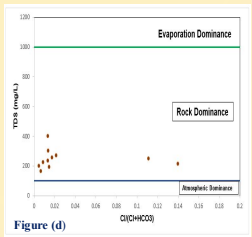


Figure (d)

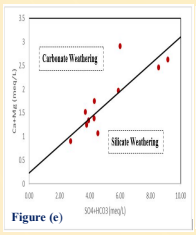


Figure (e)

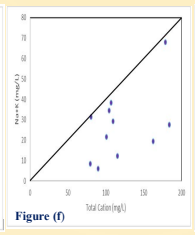


Figure (f)

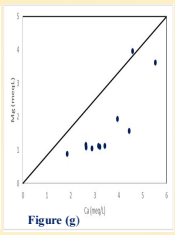

Figure (g)

**Figure 2:** (a) Piper Trilinear Plot, (b) Wilcox diagram for SAR, (c) Gibbs ratio for cation, (d) Gibbs ratio for anion,
Bivariate plot (e) Cl+SO4 vs Ca+Mg, (f) Total cation vs Na+K and (g) Ca vs Mg.

Table-1: Correlation between pairs of physiochemical parameters of groundwater quality. High correlation are shown in bold.

| Variables | pH | EC | TDS | Na | K | Ca | Mg | $HCO_3^-$ | $Cl^-$ | $SO_4^{2-}$ | $NO_3^-$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | |
| EC | -0.418 | 1 | | | | | | | | | |
| TDS | -0.014 | **0.858** | 1 | | | | | | | | |
| Na | -0.335 | 0.194 | **0.509** | 1 | | | | | | | |
| K | 0.031 | 0.289 | -0.169 | -0.242 | 1 | | | | | | |
| Ca | 0.190 | 0.032 | **0.883** | 0.084 | -0.044 | 1 | | | | | |
| Mg | 0.171 | -0.316 | **0.753** | -0.071 | -0.036 | **0.832** | 1 | | | | |
| $HCO_3^-$ | -0.033 | 0.136 | **0.984** | 0.452 | -0.226 | **0.889** | **0.738** | 1 | | | |
| $Cl^-$ | -0.203 | -0.130 | -0.352 | 0.245 | 0.400 | **-0.580** | -0.355 | -0.465 | 1 | | |
| $SO_4^{2-}$ | **-0.623** | **0.861** | 0.218 | 0.292 | 0.239 | 0.105 | -0.104 | 0.274 | -0.020 | 1 | |
| $NO_3^-$ | 0.369 | **-0.568** | -0.008 | 0.220 | 0.003 | -0.040 | -0.102 | -0.150 | 0.311 | **-0.562** | 1 |

**Table 2: Descriptive statistics of the physico-chemical properties of groundwater samples.**

| Parameters | Max | Min | Average | SD | WHO STD. (2011) |
|---|---|---|---|---|---|
| pH | 7.201 | 6.60 | 6.90 | --- | 6.5-8.5 |
| EC (µS/cm) | 614.00 | 299.00 | 429.64 | ±93.23 | <2000 |
| TDS (mg/L) | 365.11 | 153.18 | 235.30 | ±23.03 | <500 |
| Turbidity (NTU) | 104.90 | 11.97 | 54.77 | ±10.76 | <5.0 |
| TH (mg/L) | 456.68 | 136.34 | 258.19 | ±30.77 | <500.0 |
| Na (mg/L) | 67.04 | 4.95 | 25.90 | ±5.23 | <200.0 |
| K (mg/L) | 1.79 | 0.52 | 1.09 | ±0.13 | <10.0 |
| Ca (mg/L) | 110.61 | 37.02 | 69.65 | ±6.37 | <75.0 |
| Mg (mg/L) | 48.09 | 10.68 | 20.50 | ±3.96 | <50.0 |
| $HCO_3^-$ (mg/L) | 170.00 | 52.00 | 102.36 | ±12.04 | <250.0 |
| $SO_4^{2-}$ (mg/L) | 8.01 | 1.03 | 3.08 | ±0.64 | <250.0 |
| $Cl^-$ (mg/L) | 9.02 | 0.76 | 2.67 | ±0.92 | <250.0 |
| $NO_3^-$ (mg/L) | 13.11 | 1.30 | 7.63 | ±1.11 | <50.0 |

**Table 3: Calculated parameters for irrigation quality.**

| Parameter | Range | Class | Samples (%)* |
|---|---|---|---|
| EC (Electrical Conductivity) | <250<br>250-750<br>750-2000<br>2000-3000 | Excellent<br>Good<br>Permissible<br>Doubtful | 100% samples (11) |
| TH (Total Hardness) | <75<br>75-150<br>150-300<br>>300 | Soft<br>Moderately Hard<br>Hard<br>Very hard | 9% sample (1)<br>64% samples (7)<br>29% samples (3) |
| SAR (Sodium Adsorption Ratio) | 0-10<br>10-18<br>18-26<br>>26 | Use for all soil types<br>Preferably use on coarse textured soil<br>May produce harmful effects<br>Unsatisfactory | 100% samples (11) |
| SSP (Soluble Sodium Percentage) | <20<br>20-40<br>40-60<br>60-80<br>>80 | Excellent<br>Good<br>Permissible<br>Doubtful<br>Unsuitable | 45% samples (5)<br>55% samples (6) |
| RSC (Residual Sodium Carbonate) | <1.25<br>1.25-2.5<br>>2.5 | Safe<br>Marginally suitable<br>Unsuitable | 18% samples (2)<br>82% samples (9) |
| PS (Potential Salinity) | <3<br>>3 | Suitable<br>Unsuitable | 100% samples (11) |
| KR (Kelly's Ratio) | <1<br>>1 | Suitable<br>Unsuitable | 100% samples (11) |
| PI (Permeability Index) | Class I (<75%)<br>Class II (75-25%)<br>Class III (>25%) | Excellent<br>Good<br>Unsuitable | 29% samples (3)<br>71% samples (8) |
| MH (Magnesium Hazard) | <50<br>>50 | Suitable<br>Unsuitable | 100% samples (11) |
| CAI-I and CAI-II (Chloro Alkaline Indices) | Positive<br>Negative | No Base exchange<br>Base exchange | 100% samples (11) |
| r1 (Base Exchange Indices) | <1<br>>1 | $Na^+$-$SO_4^{2-}$ type water<br>$Na^+$-$HCO_3^-$ type water | 100% samples (11) |
| r2 (Meteoric Genesis Indices) | <1<br>>1 | deep meteoric percolation<br>shallow meteoric percolation | 100% samples (11) |

## Conclusions

- From all the measured physical and chemical factors, Turbidity in all samples were found much higher than WHO and Bangladesh standards. Also, the concentration of $NO_3^-$, Ca and Mg in some samples were higher than the BD std. for drinking water.
- Some irrigation parameters were analyzed and it was seen that in the aspect of EC, SAR (Wilcox diagram), %Na, KR, PS and MH the groundwater was very suitable for irrigation purpose. Although it showed some hardness as well as low PI and Marginal RSC.
- The hydro-chemistry of water indicate that base exchange occurred during water stream (CAI-I and CAI-II was negative) and the water is shallow groundwater with bicarbonate type which is very much suitable for irrigation.

However, before using these water for drinking as well as irrigation, it should be gone through some pre-treatment process to ensure better quality.

## References

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