

Al-ameri, A., Schneider, M., Janetz, S.
Institute of Geological Sciences, Hydrogeology Group

Abstract

In the present study, physico-chemical parameters were applied to characterize and classify ground- and spring water samples collected from the Sana'a basin. A total of 24 groundwater samples from deep wells and 13 spring water samples were collected from the Sana'a basin between September and October 2009 (Fig. 1). Major anions (Cl^- , HCO_3^- , NO_3^- , SO_4^{2-} and Br^-) and major cations (Ca^{2+} , Mg^{2+} , Na^+ and K^+) were measured. The physical parameters, which include water temperature, electrical conductivity and pH-value, and determination of hydrogen-carbonate, were measured on site. The ground- and spring water samples collected from the Sana'a basin were classified in groups according to their major ions. The classification was based on several hydrochemical methods, such as Ca^{2+} and Mg^{2+} hardness, Sodium Absorption Ration (SAR), Magnesium hazard (MH), saturation indices (SI) and Piper diagram

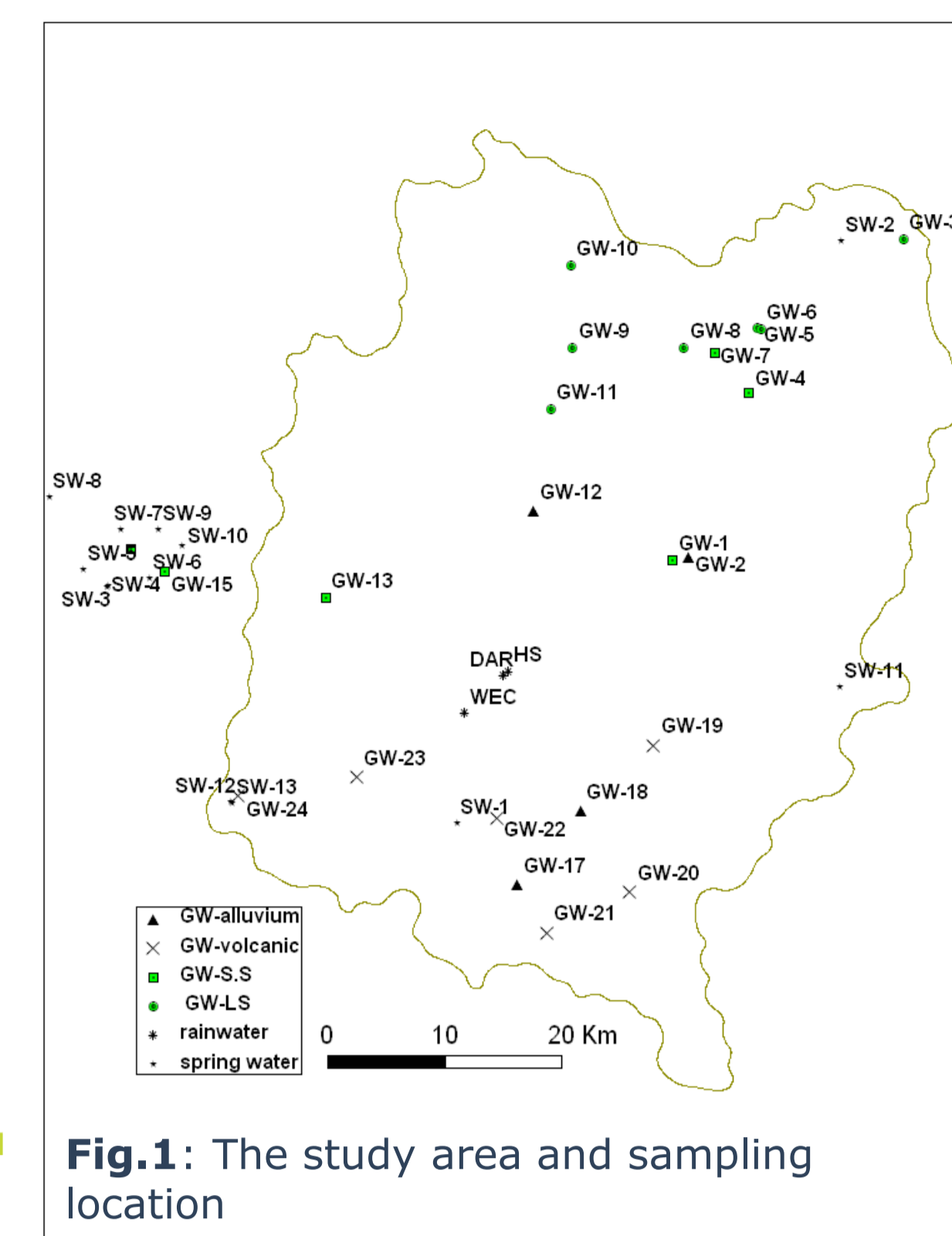


Fig. 1: The study area and sampling location

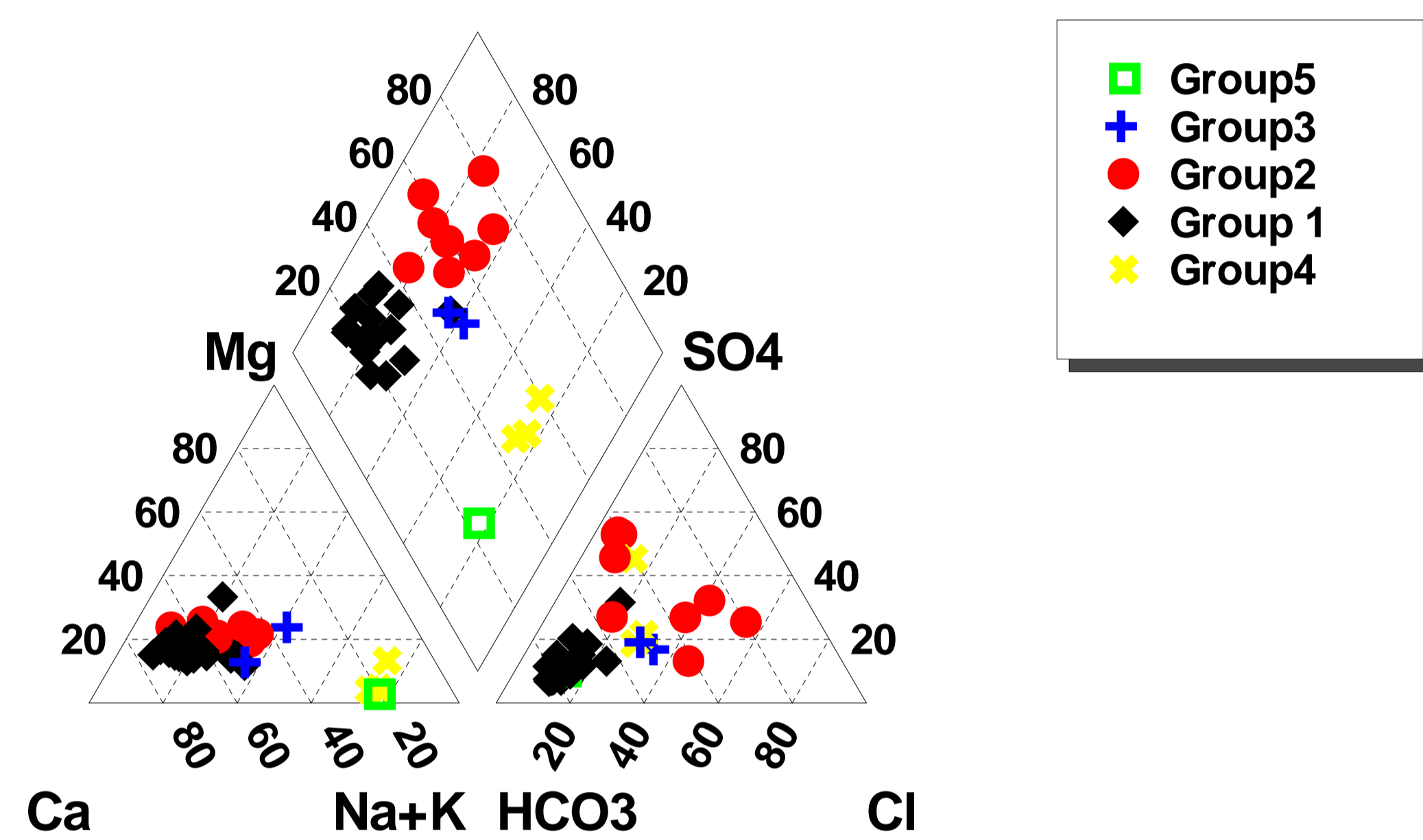


Fig. 2: Piper Plot of the water samples

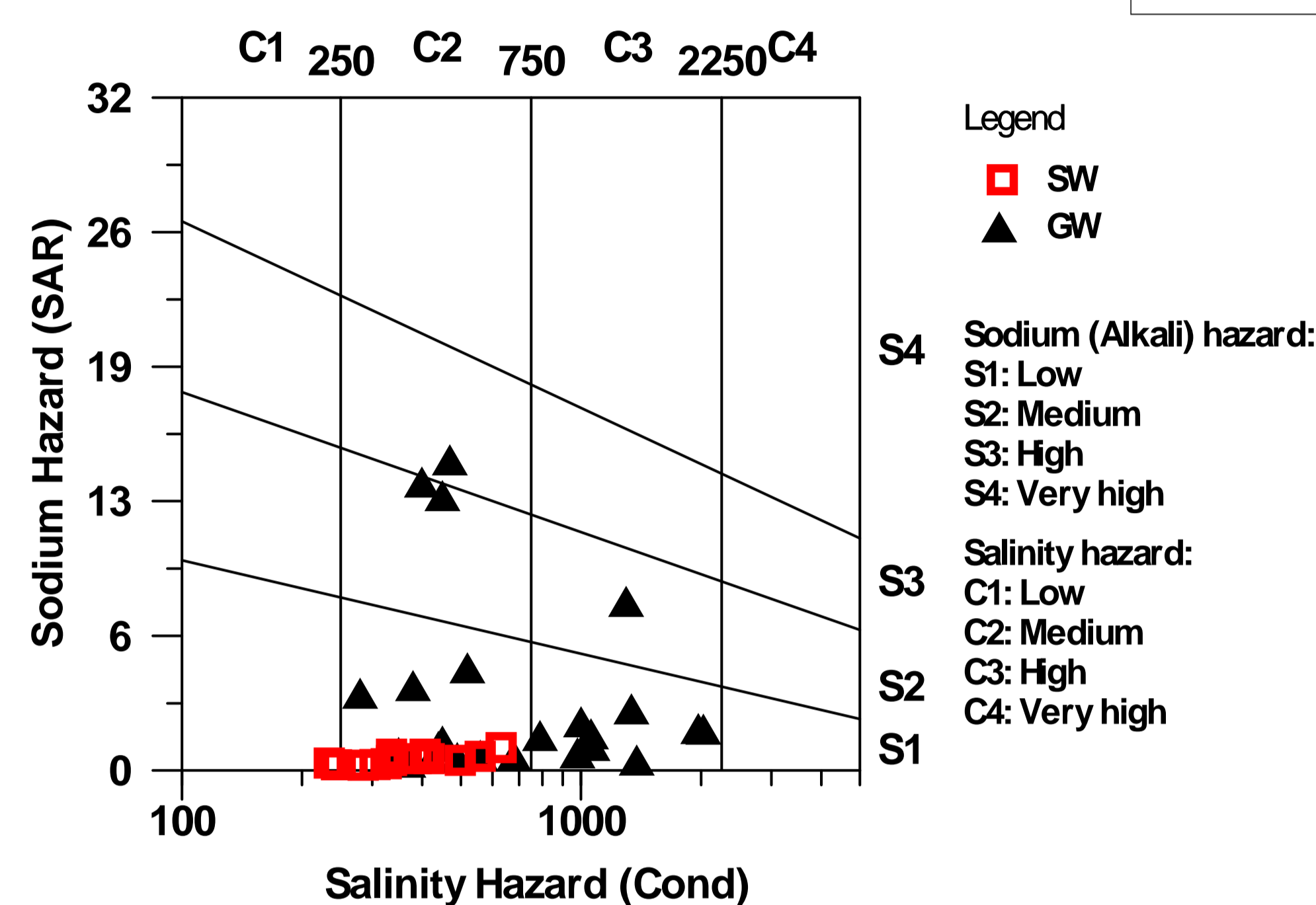


Fig. 3: U.S.S.L Plot of the Water samples

Classification based on Piper diagram (Fig.2)

Group 1: Low mineralized water of Ca- HCO_3 -type represents the major water type in the western part of the basin. Electrical conductivities range from 230 to 560 $\mu\text{S}/\text{cm}$.

Group 2: Ca-Na-Mg- HCO_3 -(SO_4 -Cl) water occurs in the north-eastern part of the basin and in the city area of Sana'a. This group is characterized by medium to high electrical conductivities ranging from 680 to 2030 $\mu\text{S}/\text{cm}$ and increased sulphate and chloride concentration accompanied by high concentration of NO_3

Group 3: Ca-Na- HCO_3 -Cl waters are characterized by moderate to high electrical conductivities ranging between 450 and 1340 $\mu\text{S}/\text{cm}$.

Group 4: The Na- HCO_3 -(SO_4 -Cl) water type occurs mainly in the volcanic aquifer in the southern part with EC values ranging from 380 to 520 $\mu\text{S}/\text{cm}$.

Group 5: (one sample): Na-K- HCO_3 characterized by low mineralization (280 $\mu\text{S}/\text{cm}$) and high concentration of alkaline minerals.

Classification based on salinity and sodium hazard (Fig.3)

Generally, the measured EC-values (ranging from 280 to 2030 $\mu\text{S}/\text{cm}$) and the calculated SAR (from 0.16 to 10.44 meq/l) indicate that the groundwater in the Sana'a basin is suitable for irrigation purposes. After RICHARDS (1954) 36 samples out of 37 are classified as 'excellent'.

Based on the USSL diagram (Fig. 3) most of the samples fall in the categories S1 and C2-C3, indicating a low to medium sodium hazard and medium to high salinity hazard. High salinity values can be found mostly in the limestone aquifer in the northern part of the basin as a result of the dissolution of calcite, dolomite and gypsum which are prominent in the Amran Group.

Classification based on saturation indices (SI)

According to the calculated SI values, the groundwater samples are classified in three categories; most of the samples are classified to be unsaturated in calcite, dolomite, anhydrite and gypsum (Fig.4).

Classification based on total hardness (Ca^{2+} and Mg^{2+} hardness)

Based on Ca^{2+} and Mg^{2+} hardness, the samples were classified into four categories; **very hard** with values range from 181 to 1108 mg/l, **hard** (139-179 mg/l), **medium hard** (112-120 mg/l) and **soft water** (8-58 mg/l). (Fig.5).

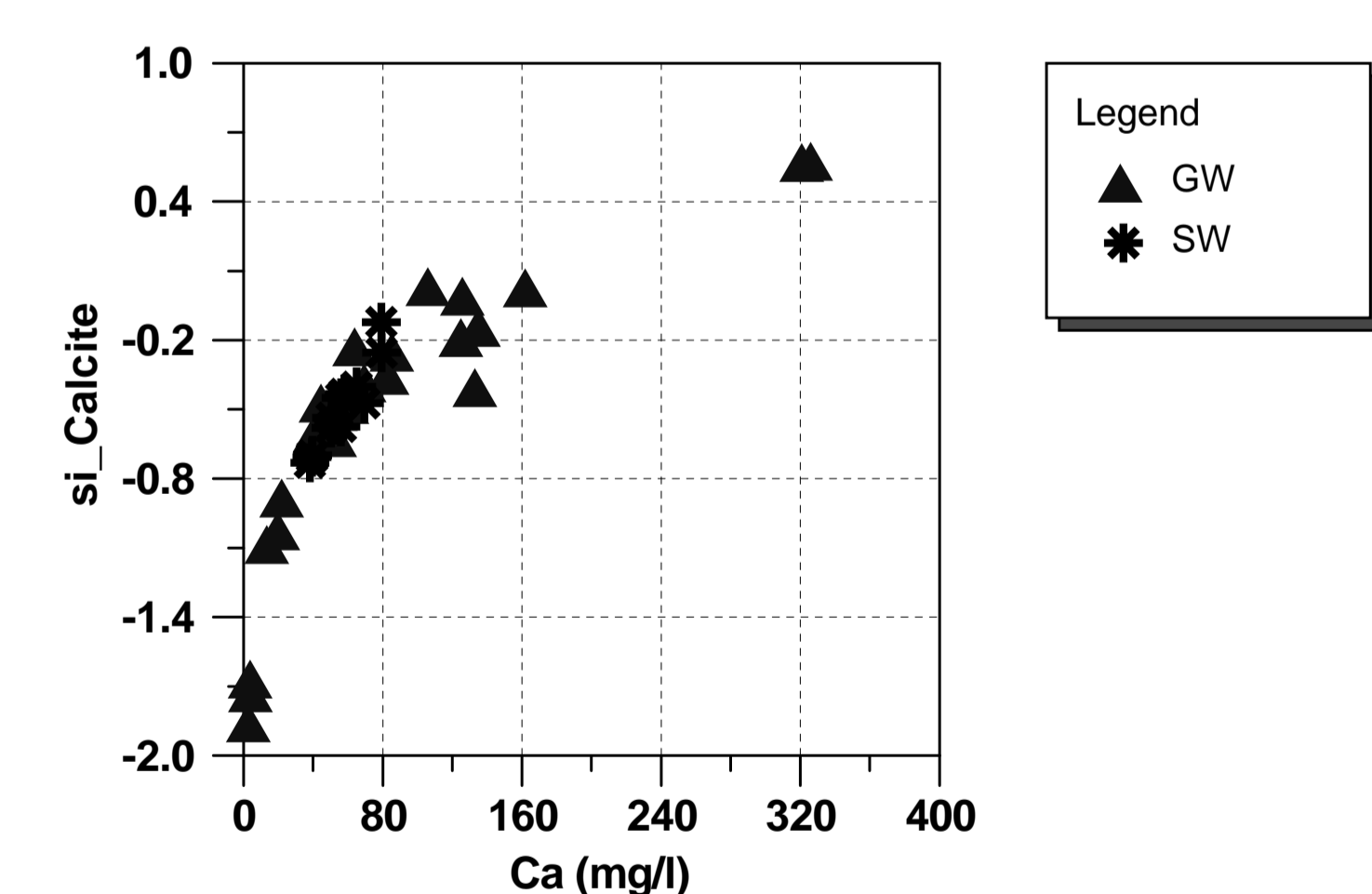


Fig. 4: SI of the water samples in respect to calcite

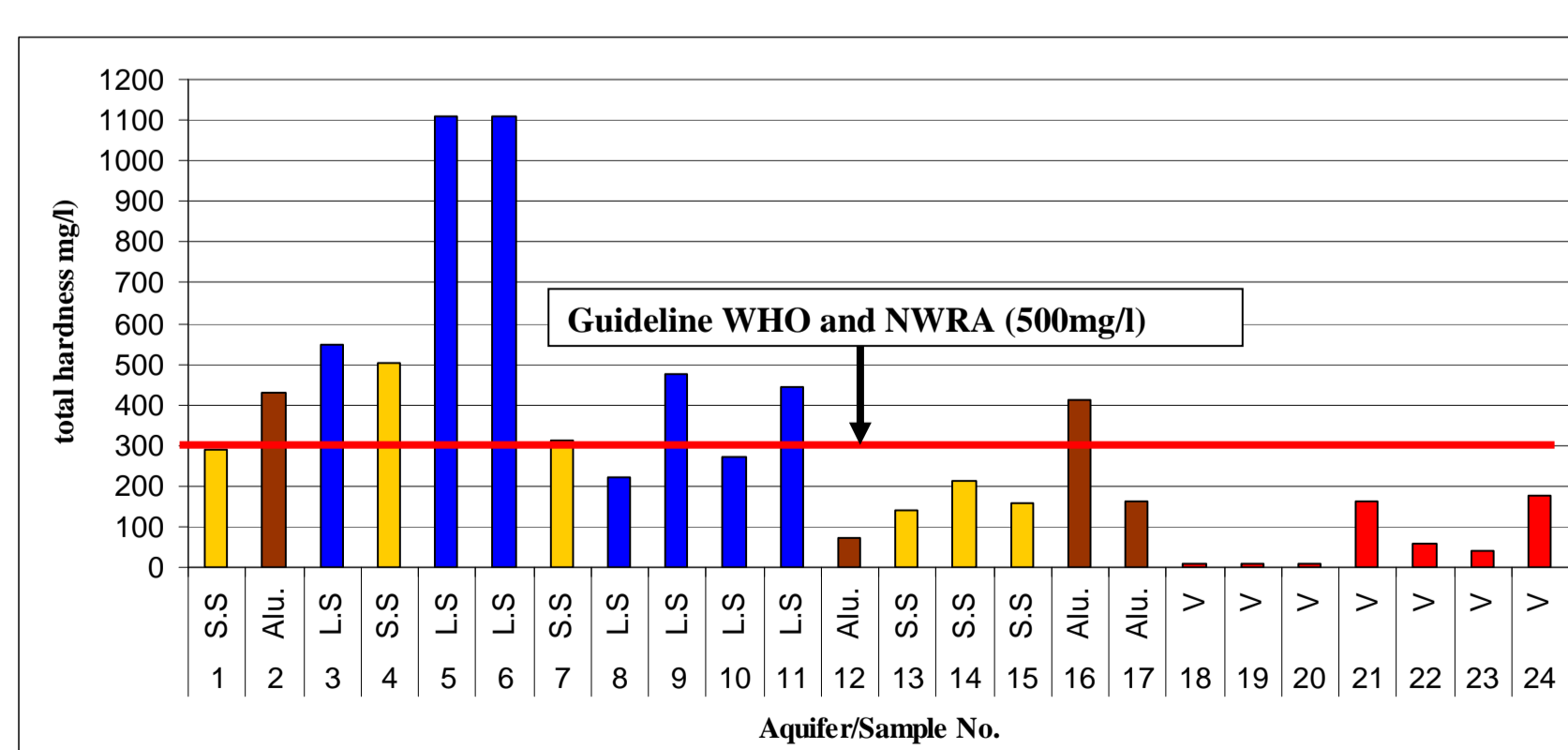


Fig. 5: Total hardness (Ca^{2+} and Mg^{2+} hardness) of the groundwater samples

Conclusions

- Elevated chloride concentrations accompanied by high concentrations of NO_3 in groundwater can be observed in the central and northern parts of Sana'a city, particularly in the alluvium and sandstone aquifer, resulting from the infiltration of wastewater.
- High EC-values are found in samples collected from the limestone aquifer in the north-eastern part of the basin due to dissolution of calcite, dolomite and gypsum which are prominent in the Amran Group.
- The groundwater quality in the Sana'a basin is considered to be suitable for domestic and irrigation purposes.