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THE COMPOSITION OF WATER COLLECTED FROM THE KUISEB RIVER,  
NAMIB DESERT, AT GOBABEB

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SUMMARY

Water from the Kuiseb River at Gobabeb varied in ionic content. Various ionic dominance orders were recorded from flooding until the pools dried up. The quality was not suitable for irrigation, but would present no problems when used by stock or wildlife.

INTRODUCTION

The Namib Desert is one of the driest deserts in the world with an average rainfall of less than 25 mm (Schulze, 1972). The Kuiseb River forms the boundary between the dune sea to the south and the stone desert to the north of the river (Figure 1). Water is of utmost importance to the biota in this arid area and the Kuiseb is usually dry. Flows of short duration do occur after heavy rainfall in the catchment area, but seldom reach its mouth near Walvis Bay. Pools and seepage water collected in animal excavations are usually the only sources of water in the Kuiseb.

Water samples were collected from the Kuiseb River at Gobabeb from 8 April to 9 August 1976. They represent water taken during a flood (April 1976) and from pools until they dried up completely.

MATERIALS AND METHODS

The water samples were collected in plastic bottles and pH and alkalinity were measured at Gobabeb before the samples were sent to Bloemfontein for the rest of the chemical analyses. The methods of chemical analyses are described by Grobbelaar (1976). Water colour was measured with a BDH Lovibond Nessleriser MK3 using NSA and NSB colour discs.

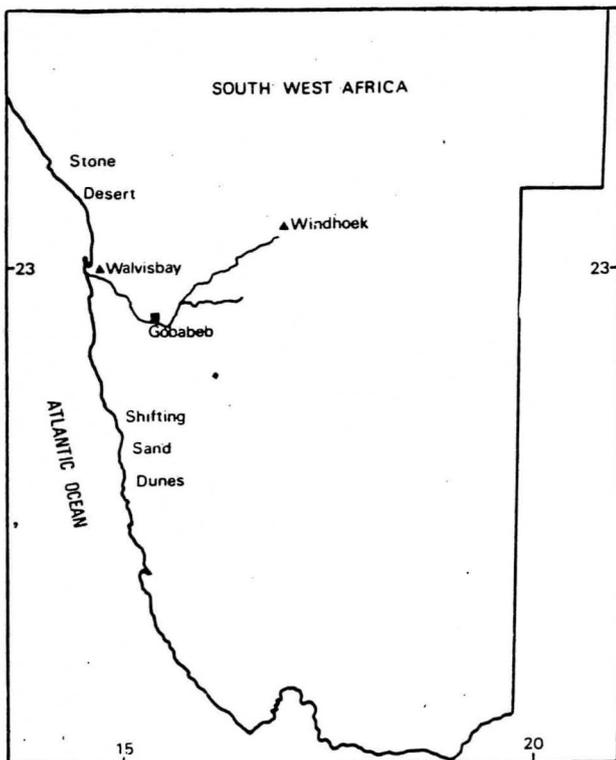


FIGURE 1. Locality map.

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RESULTS

Results of the analyses are given in Table 1. The samples represent flowing water on 8 and 15 April 1976 and stagnant pools for the rest, which dried up after 9 August 1976. Ionic diagrams for the major ions  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^-$  and  $\text{HCO}_3^-$  are shown in Figure 2.

There were marked ionic variations over the period with total dissolved solids (TDS) ranging from approximately 350 to 1900  $\text{mg l}^{-1}$ .  $\text{Na}^+$  usually, but  $\text{Ca}^{++}$  or  $\text{Mg}^{++}$  occasionally dominated the cations.  $\text{HCO}_3^-$  and  $\text{Cl}^-$  were the dominant anions. The Fe-content increased towards the end of the period, whereas Zn remained fairly constant. The reactive Si-content decreased from May to August. N and P, the biologically important nutrients, increased from April to August, when a relatively high concentration of  $\text{NH}_3\text{-N}$  was measured. A definite odour was associated with the water in July and August which was described as being "high". The colour remained fairly constant and the water was clear as shown by the low index of 50 Hazen units.

DISCUSSION

Although many workers have identified mechanisms which control the composition of freshwater, e.g. Gorham (1961) and Gibbs (1970), three factors are important in determining freshwater chemistry in the Namib Desert, as pointed out by Grobbelaar (1976). These are: 1) input of atmospheric salts some originally derived from the sea; 2) an edaphic source through weathering; and 3) evaporation and crystallization. The interplay of these factors result in the dominance orders recorded.

The importance of atmospherically derived salts has not been studied in great detail in the Namib. These could include input through rainfall, fog and dry fallout. According to Goudie (1972) fog was present at Gobabeb on an average of 102 days  $\text{a}^{-1}$  and precipitated on an average of 60 days  $\text{a}^{-1}$ . This amounted to 31  $\text{mm a}^{-1}$  which is slightly higher than the rainfall itself (23  $\text{mm a}^{-1}$ ). He also pointed out that fog frequently extends to about 110 km inland. Boss (1941), daily determined the salt content of the fog for two months and found an average of 0,4883  $\text{g l}^{-1}$  (minimum = 0,0320  $\text{g l}^{-1}$  and maximum = 2,0693  $\text{g l}^{-1}$ ). He determined that the salt is mainly NaCl and concluded that the origin is oceanic. From the work of Goudie (1972) and Boss (1941) it can be calculated that the salt input at Gobabeb must be in the order of 15  $\text{g m}^{-2} \text{a}^{-1}$ . In studying aerosol chemistry in the Namib, Van Grieken, Adams and Winchester (1978) found that the aerosols were stable and well mixed. They found that K, Ca, Ti, Mn and Fe could be identified with a dust dispersion source and that Cl, large particle S and Br, and part of the Sr are derived from sea spray.

During the wet period (8 to 22 April 1976) when flowing water was sampled,  $\text{Ca}(\text{HCO}_3)_2$  and NaCl dominated the water chemistry. These two salts were identified as the end members of the world's surface

Parameter	Date 1976										
	8/4	15/4	22/4	1/5	8/5	16/5	23/5	30/5	28/6	30/7	9/8
pH	8,25	7,83	8,21	7,68	7,81	7,30	7,30	7,95	7,70	9,18	9,11
Alkalinity	3,15	4,50	3,25	3,82	7,85	12,60	8,70	7,25	6,20	5,75	8,25
Conductivity	569,0	601,0	608,0	530,0	nd						
Na	59,0	56,0	54,0	45,0	140,0	180,0	79,0	160,0	8,85	29,25	21,75
K	8,1	9,0	7,8	6,9	19,5	24,3	20,0	18,0	21,5	34,7	49,0
Ca	40,0	53,0	47,0	42,0	74,0	140,0	67,0	99,0	94,0	75,0	62,0
Mg	11,25	15,0	15,0	12,5	45,0	105,0	75,0	57,5	29,0	78,0	54,4
Cl	30,7	59,8	64,2	44,5	301,2	581,5	230,8	448,8	144,7	68,0	78,9
SO <sub>4</sub>	14,0	9,9	9,6	5,1	8,2	22,5	1,2	9,7	35,6	16,8	48,1
Fe	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,0	0,22	0,25	1,34
Zn	0,7	0,75	1,0	1,0	1,5	0,5	0,45	0,5	0,11	0,1	0,43
Si	nd	nd	nd	nd	6,08	5,94	5,08	5,92	3,5	1,1	1,2
NO <sub>3</sub> -N	0,0	0,0	0,0	0,0	0,0	0,0	2,0	0,0	4,85	2,24	1,12
NH <sub>3</sub> -N	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,34	7,60	10,32
PO <sub>4</sub> -P	0,045	0,049	0,077	0,091	0,011	0,0	0,03	0,01	0,216	0,081	0,134
Colour	5	20	15	30	40	30	50	40	nd	nd	nd

nd = not determined

TABLE 1. Results of the chemical analysis, where conductivity is in  $\mu\text{S cm}^{-1}$ , alkalinity in  $\text{meq l}^{-1}$ , ions in  $\text{mg l}^{-1}$  and colour in Hazen units.

waters (Gibbs, 1970). This is because  $\text{Ca}(\text{HCO}_3)_2$  and  $\text{CaCO}_3$  dominate in freshwaters or rock dominated water and NaCl in high-saline waters or sea water. The water composition during the flood was, therefore, a mixture of oceanic or saline and fresh or rock dominated water.

After the wet period the water composition was dominated by  $\text{CaCO}_3$ ,  $\text{NaHCO}_3$ , NaCl and  $\text{MgCO}_3$  (Figure 2). The  $\text{CaCO}_3$  is of edaphic origin and as pointed out by Grobbelaar (1976) it is lost through precipitation from the water, when the alkalinity increases through concentration by evaporation.  $\text{Na}^+$ , because of its high mobility then dominates with  $\text{HCO}_3^-$ .  $\text{Cl}^-$  also has a high mobility and as the  $\text{CO}_3^{2-}$  is precipitated

with the  $\text{Ca}^{++}$ , it is to be expected that NaCl will dominate under certain conditions. The excessive  $\text{Ca}^{++}$  removed through precipitation from the water can explain the  $\text{MgCO}_3$  domination just before the pool dried up in August 1976. This is possible, since the solubilities of  $\text{CaCO}_3$  and  $\text{MgCO}_3$  differ at different pH's.  $\text{MgCO}_3$  will be more soluble under alkaline conditions than  $\text{CaCO}_3$ . It should also be noted that the NaCl-content of the water decreased as the pools dried up.

The Na/(Na + Ca) ratios plotted against TDS in the Gibbs (1970) model (Figure 3) show that the water lay between rock and sea water dominance. On this part of the model, evaporation and precipitation are

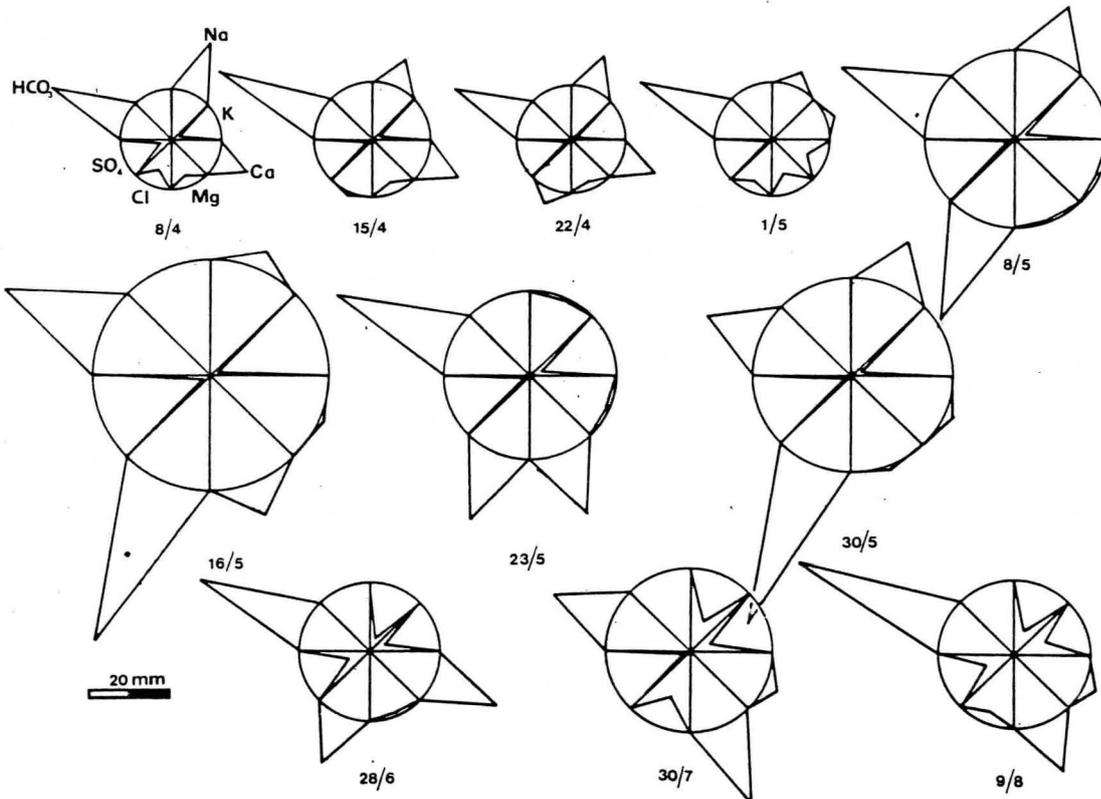


FIGURE 2. Ionic diagrams of water samples collected at Gobabeb, constructed according to Brock and Yake (1969). ( $1 \text{ mm}^2 = 0,02 \text{ meq l}^{-1}$ )

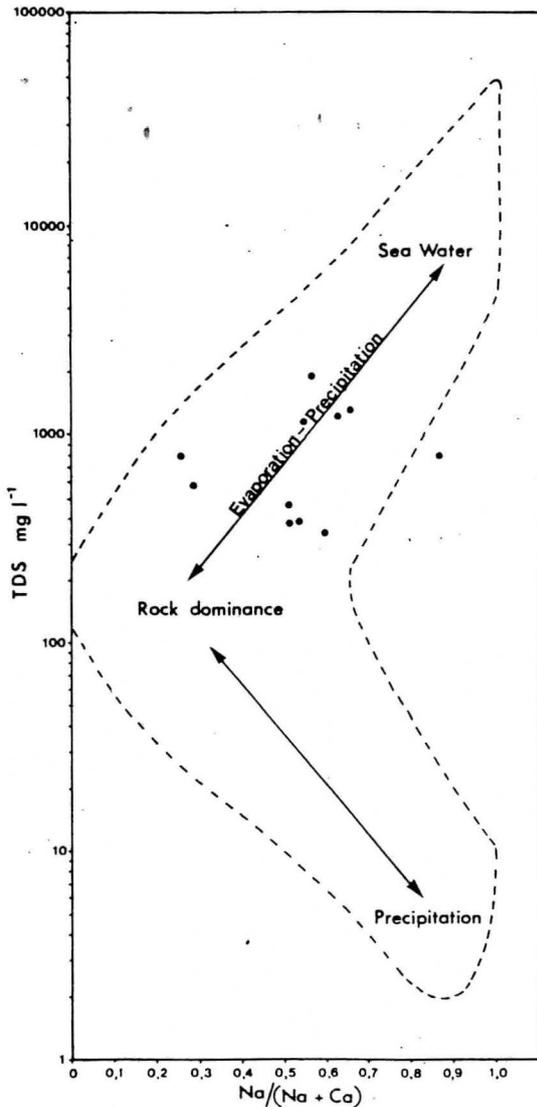


FIGURE 3. Gibbs (1970) model with points of samples collected at Gobabeb.

important factors controlling composition. The water can be classified for irrigation in the category  $S_3-N_3$  to  $S_3-N_1$  (U.S. Department of Agriculture,

1954), which is saline water suitable for use only on highly permeable soil with a risk of increasing the soil exchangeable sodium concentration. The water is, however, suitable for consumption by stock and wildlife as salinity does not exceed  $2000 \text{ mg l}^{-1}$  TDS (Clark, Viessman and Hammer, 1971).

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#### KEYWORDS

Chemical composition, water quality, Kuiseb River, chemical control factors, Namib Desert