

This is one of a series of information sheets prepared for each country in which WaterAid works. The sheets aim to identify inorganic constituents of significant risk to health that may occur in groundwater in the country in question. The purpose of the sheets is to provide guidance to WaterAid Country Office staff on targeting efforts on water-quality testing and to encourage further thinking in the organisation on water-quality issues.

## Background

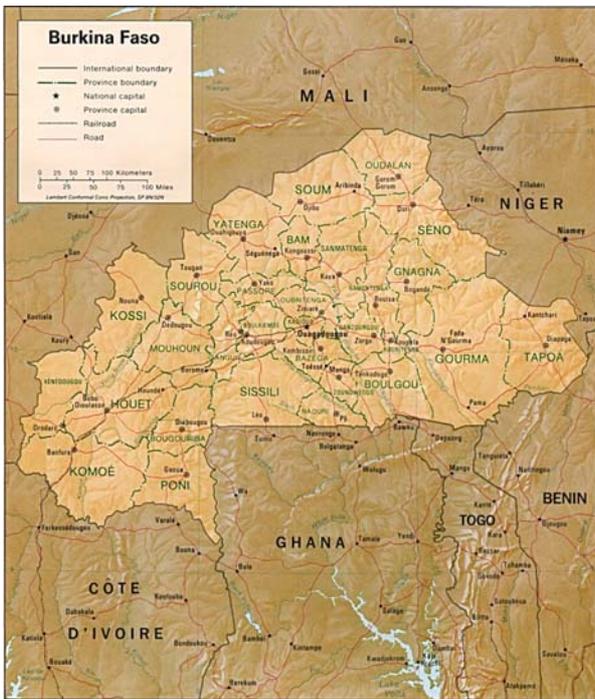
Burkina Faso is a landlocked country in the Sahel region of West Africa. It has an area of around 274,000 square kilometres and is bordered to the south by Cote d'Ivoire, Ghana and Togo, to the east by Benin and Niger and to the north by Mali (Figure 1).

The terrain is mainly flat or undulating with some small hills in the west and south-eastern parts. The highest point is Tena Kourou (749 m), close to the Mali border, and the lowest point on the Black Volta River (200 m) in the south-eastern part of the country. The Volta Basin occupies around two-thirds of the country and the Black Volta (Monhoun), Red Volta (Nazinon) and White Volta (Nakambé) Rivers all have their sources in Burkina Faso. The Black Volta is the only perennial river. Many of the river courses are dammed in order to

accumulate water in the rainy season.

The climate varies from arid in the north to tropical savannah in the south. The country has warm dry winters resulting from northerly Saharan air masses and hot, wet summers from moist Atlantic air. Average annual rainfall decreases from around 1200 mm in the south to 650 mm in the north (around 850 mm in Ouagadougou) and the rainy season lasts from June to October. However, rainfall is often irregular and the region is prone to droughts, especially in the north. Average daytime temperatures range from 30°C in the south to 40°C in the north.

Land use comprises mainly woodland, forest and pastureland with around 13% used for arable agriculture. Some 90% of the population is engaged in subsistence farming. Principal crops produced are peanuts, shea nuts, sesame, cotton, sorghum, millet and corn. The principal industries are cotton lint, beverage manufacture, brewing and agricultural and leather processing.



**Figure 1. Relief map of Burkina Faso (courtesy of The General Libraries, The University of Texas at Austin).**

## Geology

The geology of Burkina Faso comprises dominantly ancient (Precambrian) crystalline rocks, consisting of metamorphosed sediments, meta-igneous rocks and abundant intrusive granite. The backbone of the country is composed of Archaean (3000–2700 million years old) crystalline rocks but intercalations of younger (Birimian) crystalline rocks are also common. These are similar to the formations developed in neighbouring Ghana and other parts of West Africa. The margins of a large ancient sedimentary basin (Precambrian to Ordovician age) occupy the western border area. This formation is represented by sandstone, shale and dolomite (limestone). Younger rocks (Mesozoic to Quaternary age) are restricted to sedimentary basins in the extreme north of the country (Gondo Plain), along the border with Mali. Much of this area accommodates the Tertiary Formation of the ‘Terminal Continental’ (UN, 1988).

Burkina Faso has a rich reserve of gold deposits, with the gold occurring along with quartz and occasionally sulphide minerals in veins from a number of areas in the crystalline basement (mainly Birimian age rocks), as well as deposited in alluvial gravels. Gold deposits in mineralised veins have been found in Poura, Dori-Yalago, Aribinda, Dossi-Kière, Essakane, Yako-Kaya and Kwademen areas (EU/WCAMF, 1998). With the exception of the Essakane and Poura deposits which have been mined by larger commercial operations, most gold-mining activity is artisanal. Commercial operations at the principal mine, Poura, were suspended in 1999. Most of the gold reserves are located in the northern part of the country, although Poura and Dossi are located in the south-west (Boromo area; Figure 1).

Burkina Faso also has economic reserves of manganese, phosphate and zinc, the latter contained in sulphide ore bodies within the Birimian basement complex. In addition, intrusive pipes of igneous rock are diamondiferous in places (Nixon, 1995).

Areas of crystalline bedrock are generally capped by a layer of weathered and often clayey rock ("overburden"), commonly 20–100 m in thickness (Groen et al., 1988). This in turn is typically capped by a layer of weathered lateritic (iron-rich and hardened) soil.

### **Groundwater Availability**

Given the climatic conditions of Burkina Faso, surface water is in limited supply and groundwater is therefore an important resource. Rural water supply projects rely mainly on groundwater, although this is also scarce in many areas. Dammed river courses typically provide urban supplies. Only around 25% of the population has access to safe drinking water. Traditional sources of water were hand-dug wells (as well as ponds used in the rainy season). Today, groundwater is also abstracted from a number of tubewells, typically equipped with handpumps. Tubewells generally source groundwater from fractures within the basement complex, while hand-dug wells are largely sourced from the weathered overburden layer. Yields from tubewells and dug wells in the basement areas are generally low and many dry up seasonally (UN, 1988). Rare Precambrian dolomitic limestone in the west of the country gives rise to perennial springs (e.g. around Kou; UN, 1988). Indurated sandstones in the ancient basement rocks also provide some groundwater. Groen et al. (1988) noted groundwater levels in basement rocks from north-western Burkina Faso of some 10–60 m below surface with a seasonal variation of around 1–2 m. Declining groundwater levels have been reported in some areas in recent years (UN, 1988).

In the sedimentary rock formations along the north-west border region, groundwater availability is also limited, although the dolomitic limestones form the best aquifers. The younger sedimentary formations cropping out in the north constitute a small aquifer which is connected with underlying dolomitic limestone. In the Terminal Continental of the Gondo Plain, tubewells often need to be deep to exploit permeable aquifers.

### **Groundwater Quality**

#### *Overview*

As with many arid African countries, groundwater quality has been an issue of lower priority than groundwater availability and has hence received relatively little attention. Hence, few data exist on which to provide an adequate assessment of the quality of the nation's groundwater. From the data available, the groundwater from the basement rocks is typically fresh, with Ca-Mg-HCO<sub>3</sub>-dominant water types. Investigations suggest that pollution from contaminants such as nitrate is a common problem, especially in shallow groundwater sources. Arsenic has also been identified as a problem in some areas. The extent of occurrence of high-arsenic water is not known; recognised problems appear to be localised to one or two villages. Few other water-quality problems have been singled out as major issues.

#### *Nitrogen species*

Shallow groundwater has significant potential for being contaminated by pollutants from domestic (latrines, drains, waste tips) as well as agricultural and industrial sources. Groen et al. (1988) noted the occurrence of nitrate at concentrations above the WHO guideline value in several groundwater samples from tubewells and open dug wells in north-western Burkina Faso. In a study of 168 tubewell samples, 15% were found to have NO<sub>3</sub>-N concentrations greater than 10 mg/l. In addition, of 123 samples of well water investigated, 36% had concentrations above this value. The maximum observed concentration was 90 mg/l (as N). Nitrate concentrations were highest in areas with increased housing density and were also elevated in groundwater downgradient of the housing areas. Increased nitrate was found to be accompanied by increased electrical conductivity, which suggests that the concentrations of many other major ions (notably chloride, sulphate, sodium, potassium) were likewise increased as a result of the pollutant inputs. High nitrate concentrations are likely to be a feature of shallow groundwaters in many areas of the country. The concentrations of ammonium and nitrite are less clear. Some exceedances above WHO

guideline values are expected, though these are likely to be less common than exceedances of nitrate.

### ***Salinity***

Groundwater abstracted from the basement aquifers and overlying weathered horizons is for the most part likely to be fresh, based on data available from Birimian aquifers elsewhere (e.g. Smedley et al., 1995). Groundwaters of low mineral content are also reported by UN (1988). However, Groen et al. (1988) found variable salinity in groundwater samples from their study of north-western Burkina Faso. Electrical conductivity values were in the range 50–2700  $\mu\text{S}/\text{cm}$ . The highest values observed are relatively saline and unsuitable for potable use. However, median values determined (270  $\mu\text{S}/\text{cm}$  and 370  $\mu\text{S}/\text{cm}$  respectively for dug wells and tubewells) indicate the presence of predominantly fresh groundwater. The salinity variations in groundwater from the sedimentary formations along the north-west and northern border areas of Burkina Faso are not known.

### ***Fluoride***

No fluoride data are currently available for Burkina Faso groundwater. Smedley et al. (1995) reported often high fluoride concentrations (up to 3.8 mg/l) in some granites and some meta-igneous horizons in the Birimian basement from the neighbouring Upper Regions of Ghana. This suggests that areas of granite especially and possibly other areas of the crystalline basement of Burkina Faso could carry groundwater with unacceptably high fluoride concentrations (greater than the WHO guideline value of 1.5 mg/l). Fluoride concentrations are likely to be higher in tubewells abstracting from the basement fractures than in shallow dug wells.

### ***Iron and manganese***

Few data are available for iron or manganese. Under shallow groundwater conditions, the aquifers are likely to be mostly oxic and hence these elements should only be present at low concentrations. Local variations in aquifer conditions may apply however, and sporadic high concentrations may occur. If groundwaters are acidic, concentrations of iron and manganese may be increased. Some groundwater abstracted from shallow lateritic horizons is noted to have high Fe concentrations for example (UN, 1988). Appreciation of the pH of the groundwaters would help to assess whether this is likely to be a problem. High iron and manganese problems may occur around the areas of sulphide mining and mineralisation. Where high iron is a problem, this should be manifest by red staining around the well

head, as well as clothes and food, and the water may have a metallic taste.

### ***Arsenic***

Limited reporting suggests that arsenic problems exist in part of Burkina Faso, although the recognised problem is said to be highly localised. De Jong and Kikietta (1981) noted the occurrence of locally high arsenic concentrations in a village (V5) close to Mogtedo in central Burkina Faso, around 60 km east of Ouagadougou. Concentrations in three boreholes (each around 40 m deep) were found to be 200, 300 and 1600  $\mu\text{g}/\text{l}$ . Appelo and Postma (1993, p248) also indicated from an original investigation carried out by IWACO (1975) that arsenic problems occur in some Burkina Faso groundwaters. The high concentrations occur in the Birimian rocks and are taken to be the result of oxidation of sulphide minerals (e.g. pyrite, arsenopyrite) and are likely to be concentrated in and around the gold mineralised areas. The presence of arsenic in the drinking water is said to have given rise to the serious chronic arsenicosis condition known as blackfoot disease. If so, this would imply the occurrence of very high concentrations in affected potable supplies (several hundreds of  $\mu\text{g}/\text{l}$ ) and is cause for concern. Verification of the location(s) of the noted health problems and instigation of a water-testing programme for arsenic, especially in the mineralised areas, would help to define the nature and scale of the problem in Burkina Faso and form the basis for provision of low-arsenic alternative water supplies.

### ***Iodine***

As with many other chemical constituents, analyses of iodine are not available for the groundwater. However, the region is arid and remote from the influences of maritime rainfall. Hence, iodine inputs from atmospheric sources are likely to be low. This, combined with the dominant hard-rock geology of the region, means that iodine concentrations in groundwaters (as well as soils and locally produced crops) are likely to be low (of the order of a few  $\mu\text{g}/\text{l}$ ). Indeed, iodine concentrations were found to be low or very low in many groundwater samples from the neighbouring Bolgatanga area of northern Ghana (Smedley et al., 1995). Hence, it is possible that iodine-deficiency problems occur in the Burkina Faso population if dietary iodine supplements are not used.

### ***Other trace elements***

No other data are available for trace elements in the groundwaters. Since sulphide-mineral oxidation has been identified as a problem resulting in arsenic

contamination, at least in some areas, there is the possibility that other potentially toxic trace elements are present in the groundwaters from the mineralised areas. Concentrations of elements such as nickel, lead, copper, cadmium, zinc, chromium and molybdenum (as well as major constituents such as sulphate) should be checked to assess the risks involved.

### Data sources

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