

7. Water quality in and around the cities

This chapter presents findings from a study done in Kumasi, aimed at assessing the water quality in water bodies in and around the city, especially those used for irrigated agriculture. Physiochemical and microbiological parameters were measured. Data obtained from previous monitoring were also reviewed and are presented for comparison. Some references have been made to Accra and Tamale.

7.1 Key indicators

The quality of water applied has implications for crop and soil productivity and consumers' health. The FAO and WHO guidelines on quality of irrigation water are the basis for national guidelines in many countries. Where domestic wastewater is the main source of water pollution, the two main indicators from the health perspective are Faecal Coliforms (FC colonies/100ml) and Helminth eggs (eggs/100 ml). These and other indicators, like BOD, are briefly explained in Box 6.1 of the previous chapter.

Limits to these parameters depend on the types of crops grown. For vegetables likely to be eaten raw, the irrigation water should in the ideal case have less than 1×10^3 faecal coliforms per 100 ml and ≤ 1 nematode egg per litre (WHO, 1989, 2006).

7.2 Sampling sites and methods

Fourteen sampling sites used for irrigation were selected in upstream and downstream locations of Kumasi along the major streams and rivers (Figure 7.1). These locations correspond in part with those used before by Cornish et al. (1999) and McGregor et al. (2002). Besides the major streams, two shallow wells close to streams were also sampled. Water samples were collected and taken for analysis in accordance with standard methods of water quality sampling and analysis (APHA, 1989). Parameters analysed included pH, Electrical Conductivity (EC), Ammonium- Nitrogen ($\text{NH}_3\text{-N}$), Nitrate – Nitrogen ($\text{NO}_3\text{-N}$), Phosphates ($\text{PO}_4\text{-P}$), Potassium (K), Faecal coliforms (FC) and Total coliforms (TC). The choice of parameters depended on their agricultural significance and ability of local labs to analyse them. A total of seven samples were collected from each site at 2-4 week intervals. These were done over a one-year period from the beginning of February to the end of June 2002, covering both dry and wet seasons. Rainfall data was taken from the nearby Kumasi met station.

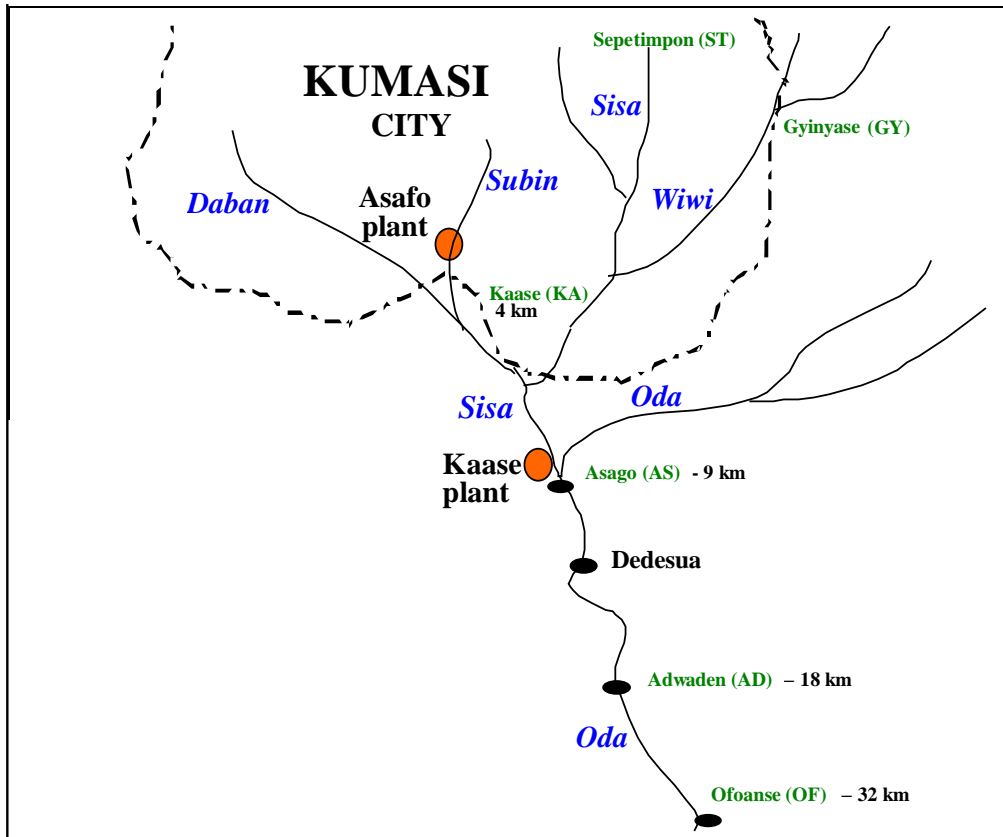


Figure 7.1: Stream network in and around Kumasi and some water sampling sites

7.3 Changes in water quality along the main streams

The Subin river, which originates from the heart of Kumasi and serves as storm water – cum wastewater channel (see Chapter 6), is heavily polluted by faecal and total coliforms, and shows low dissolved oxygen and high conductivity. This probably reflects the night soil dumping, direct disposal of domestic and all kinds of wastes from the urban areas. Animal skin dressing and piggery activities between the main wastewater source and the Subin River substantially prejudice pollution effects of source effluent on the river. Wastewater from the source shows a fairly consistent trend of high values in conductivity, turbidity and coliforms.

Many people rely on the stream and its tributaries for their domestic use (few have pipe-borne water) and for irrigation. The changes in water quality in streams in and around Kumasi are evident, and complaints have been coming from users, especially in Asago Village, 9 km from the city center, just downstream of the Kaase faecal treatment plant where the Sisa enters the Oda river.

The pH levels had few variations, ranging from 6.8 –7.2, which are in the normal range for irrigation water. The salinity levels were also low (EC <1 dS/m) and decrease downstream. Also, there is a significant difference in NH_4 between upstream and downstream (Figure 7.2) and there is a typical decline of the nutrient levels with increasing distance from the city (Figure 7.3). Compared to normal poultry manure application in vegetable production, the fertilizer effect of irrigation water is in general insignificant along the Subin and Sisa (Drechsel et al., 2005).

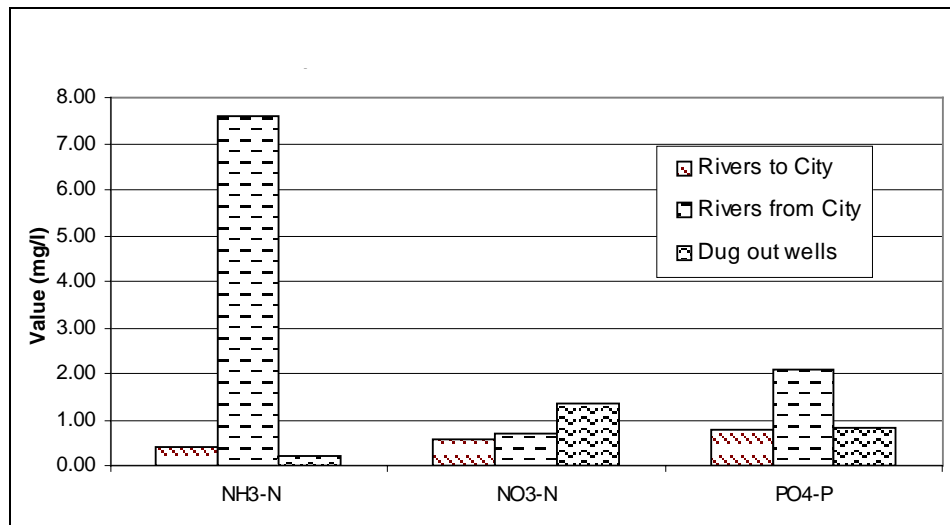


Figure 7.2: Comparison of average nutrient levels at different sampling locations

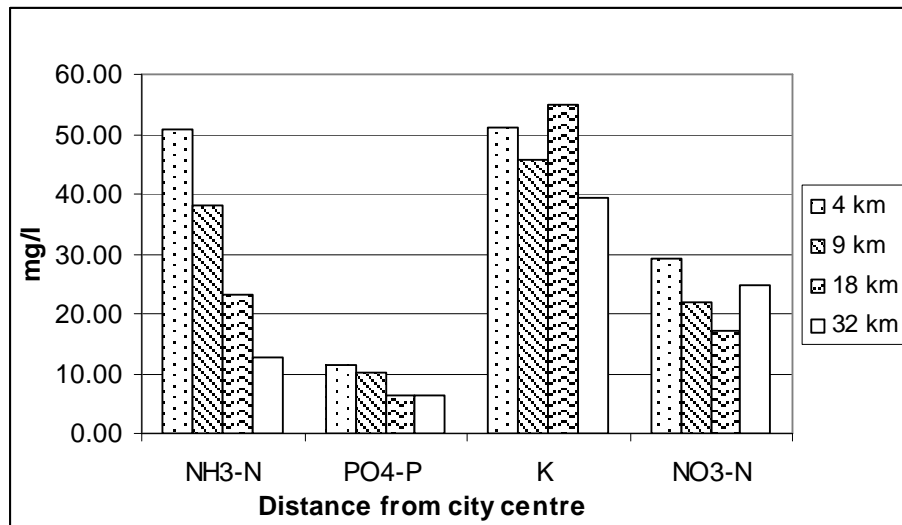


Figure 7.3: Variations of chemical parameters in downstream Kumasi

Microbiological pollution also followed the same declining trend with increasing distance from the city (Figure 7.4). For instance, total coliforms as indicator of faeces dropped from 3.5×10^{10} counts 4 km away from the city center to 1.7×10^8 counts 18 km downstream. The same was observed for faecal coliforms. High coliform and $\text{NH}_3\text{-N}$ in downstream water bodies could be associated with lack of adequate sanitation facilities and non-functional sanitation infrastructure, especially the Kaase faecal sludge treatment plant. It is worthwhile to note that in contrast to nutrient levels, the pathogen contamination of the stream remains high (more than $10^6/100$ ml) even 32 km downstream of the city, which is a serious health concern to users of this water source.

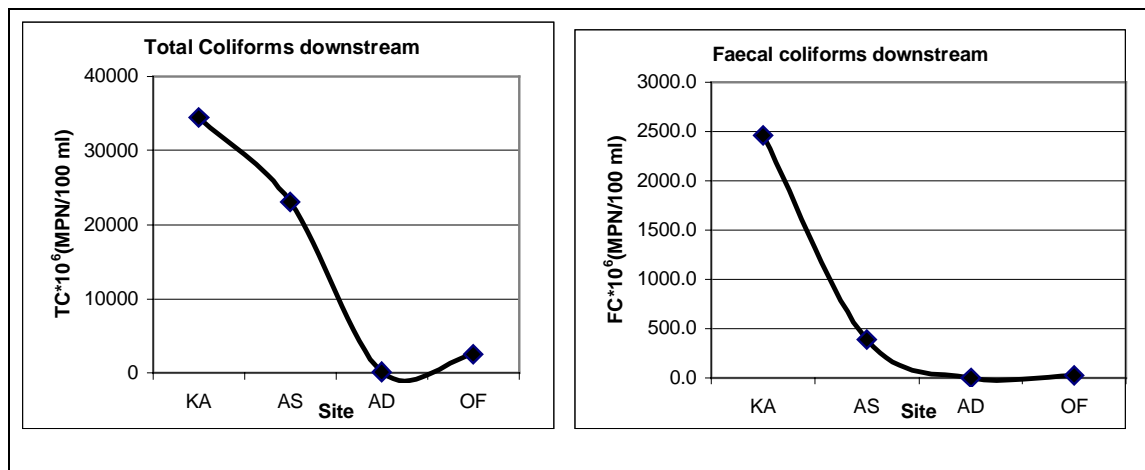


Figure 7.4: Changes in coliform levels downstream

Industrial wastewater is not significant in quantitative terms in Kumasi as there is limited industrial development mainly because Kumasi is an inland city. The main generators of industrial wastewater in Kumasi are the two breweries, a soft drink bottling plant and the abattoir generating a total of about 1000 m^3 of effluents daily which also end up in the city's drains and nearby streams (Simon et al., 2001, Keraita, 2002). There are light-industry activities, which generate significant amounts of non-collected waste oil and leachate.

Heavy metal contamination remains localized. In most cases, the stream metal levels do not exceed common norms in and around Kumasi (McGregor et al., 2002; Cornish et al., 1999; Mensah et al., 2001). The situation can be different in Ghana's rural gold mining areas, or, for example, in the cities of Kano (Nigeria) or Ouagadougou (Burkina Faso), which are known for their tanneries and water contamination e.g. with Chromium (Drechsel et al., 2006a).

7.4 Seasonal variations of coliform levels

Figure 7.5 shows the influence of rainfall on coliform levels at two locations, both downstream of Kumasi monitored over a 6-month period. There is a general increase in levels of faecal coliforms after the first rains and this continues for about two months before the levels start decreasing. In general, there was a bit of correlation between rainfall and coli counts, but more data should be collected over many seasons to clearly establish the relationship. Faruqui et al. (2004), for example, mention the effects of “laundry days” and “Friday prayers” on stream water quality. This piece of information can be used to advise water users to avoid or to be more cautious when using water from these sources at particular times of the day, week or season to reduce negative health impact.

There was no significant trend in the variation of the nutrient load across the seasons. $\text{NO}_3\text{-N}$ levels increased almost immediately after the first rains and as the rains continued, the levels decreased over the next three months after which they remained constant. The immediate response can be attributed to mineralization processes of organic debris starting with the first rains and the highly soluble nature of nitrates.

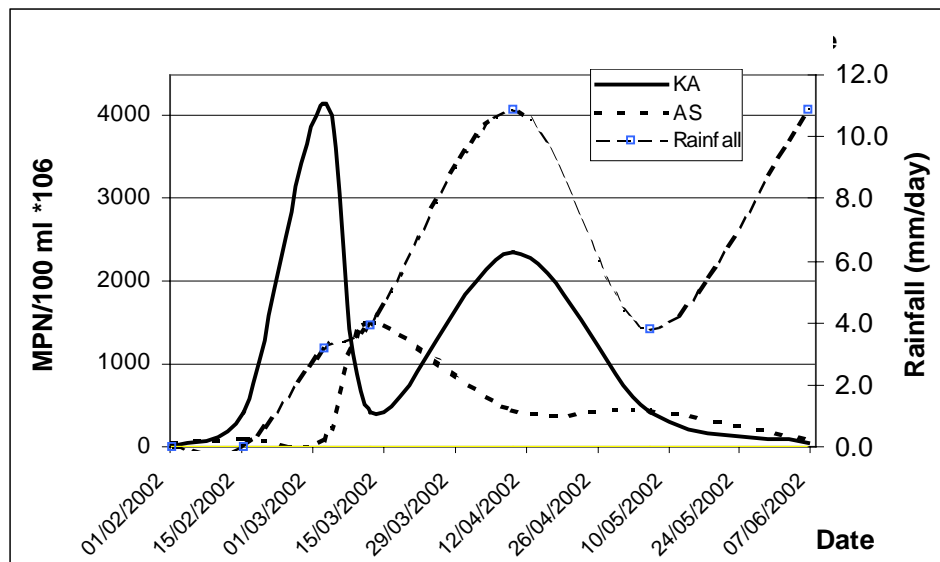


Figure 7.5: Faecal coliform changes over seasons

Figure 7.6 is derived from Cornish et al (1999). The authors monitored stream water quality over the dry-wet season interface over one-month in February/March, 1999. This showed also an increase in the PO₄-P levels for about two weeks after the onset of the rains.

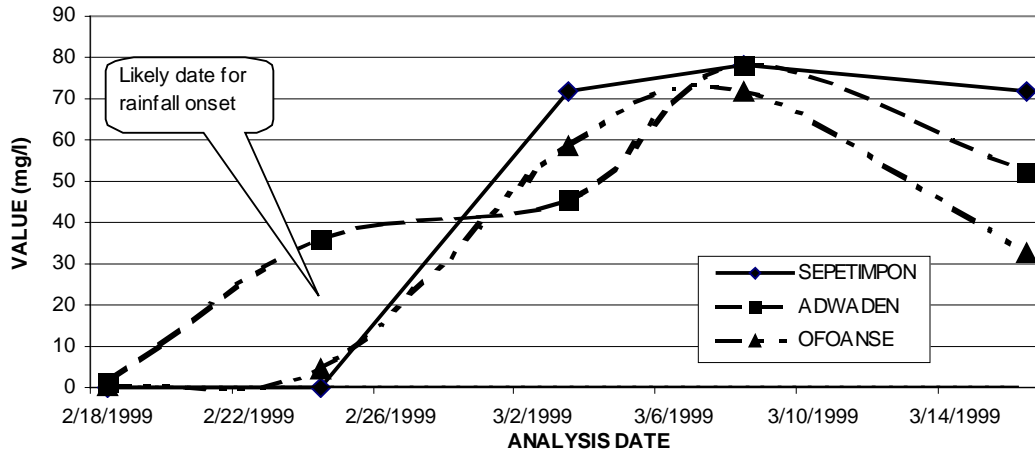


Figure 7.6: PO₄-P variations on dry-wet season interface (Cornish et al., 1999)

Water quality monitoring by Ghana's EPA between 1999 and 2001 showed high variations in contamination levels (McGregor et al., 2002). This underlines that the conclusions drawn are only indicative and therefore subject to verification after longer measurement periods. The need for regular monitoring is evident.

7.5 Water quality in vegetable farming sites

Amoah et al. (2005, 2006b) sampled irrigation water (specifically for coliform levels) in the main urban farming sites in Accra and Kumasi. In Accra, faecal coliform levels ranged from 10¹-10⁷/100 ml (Table 7.1). The lower values were recorded in Dzorwulu where farmers use pipe water stored in shallow wells. Farming sites in Korle-bu, La and Marine Drive where farmers use water from urban drains for irrigation recorded the higher values. Previous studies carried out in Accra (Armar-Klemesu et al., 1998; Sonou, 2001, Zakariah et al., 1998) also showed that there are hardly any unpolluted water sources available for irrigation. The worst case is the highly populated drainage basin of the Odaw river/Korle Lagoon, which covers more than 60% of Accra. Its year-2000 BOD load has been estimated as 132,000 kg/day (Biney, 1998).

In Tamale, the highest level of faecal coliform levels was recorded at Kamina, where farmers use a broken down sewage pond for irrigation purposes. However, most of the vegetables grown here are traditional ones, which are eaten cooked and may pose less or no risks to consumers. Figure 7.7 shows the levels in other sites. Like in Accra, water in Tamale is scarce and farmers have no choice other than to use water from storm water drains polluted with domestic wastewater (Abdul-Ghaniyu et al., 2002).

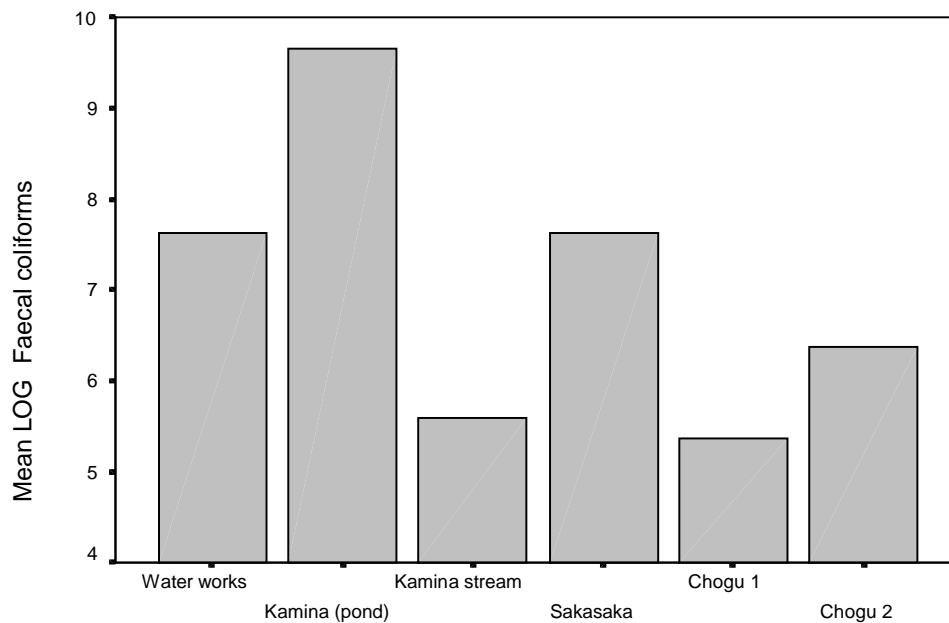


Figure 7.7: Faecal coliform levels in main urban vegetable farming sites in Tamale (Amoah, unpubl.)

Shallow wells (dugouts close to streams) had in general better quality water than the streams, but showed in many cases relatively high coliform levels of $10^6/100$ ml. These were associated with water entering the wells and the extensive use of (fresh) poultry manure in vegetable farming. Cornish et al. (1999) observed the same phenomenon that shallow wells do not always offer a cleaner water source than streams and rivers and recommended improvements to avoid run-off entering the wells.

As mentioned in the previous section (7.4), the analysis of heavy metal concentrations in streams used for irrigation in and around Kumasi did not show any alarming values. The same seems to apply to Accra as preliminary data provided by Mensah et al. (2001) indicate.

Table 7.1: Water quality and crops on selected urban farming sites in Accra and Kumasi

Location	Sources and quality of irrigation water	Crops
Marine Drive, Accra	Faecal coliforms (FC) up to 10^{6-7} / 100 ml; Electrical conductivity (EC): 0.7-1.1 ds/m; irrigation with watering cans	Lettuce, green pepper, spring onions, cucumber etc.
Dzorwulu, Accra	1. River Onyasia with contributions of wastewater from neighbouring settlements (FC up to 10^{5-6} / 100 ml); irrigation with watering cans 2. Piped water; irrigation with drag hoses or watering cans (FC < 10^1 / 100 ml);	Lettuce, cucumber, Cabbage, Cauliflower, onion, Chinese cabbage, spring onions, radish, spinach etc
Korle Bu, Accra	Drain water from hospital staff houses and shallow wells (FC up to 10^8 / 100 ml); irrigation with watering cans	Lettuce, cabbage, spring onions, ayoyo, alefu, etc
La, Accra	Wastewater from the Burma Camp barracks, partially treated (FC still up to 10^6 per 100 ml); Irrigation of okra, maize and other tall crops by furrows; irrigation of vegetables by watering cans around the last treatment pond	Cabbage, lettuce, sweet pepper, okra, maize etc
Gyinyase 1 Kumasi	Stream water and shallow wells (Total Dissolved Solids (TDS): 1840 mg/l, pH: 7.5); irrigation with watering cans	Green pepper, lettuce, cabbage, spring onions, Ayoyo, Alefu
Gyinyase 2 Kumasi	Streams, shallow wells, which are partly enriched with run-off (TDS: 1160 mg/l; pH: 7.1). Irrigation with watering cans and furrow	Lettuce, cabbage, spring onions, green pepper, carrots
Georgia Hotel	Pipe borne water, irrigation with drag hose, watering cans, sprinklers.	Spring onions, cabbage, Ayoyo, cauliflower, Alefu, green pepper

Source: Gbireh (1999), updated and modified

7.6 Conclusions and recommendations

In Ghana, the industrial contribution to water pollution is generally low. Streams in and around Kumasi contain diluted domestic storm and wastewater with pH, EC, heavy metal and nutrient levels in the acceptable range. However, levels of faecal and total coliforms were very high, all being above $10^6/100$ ml even as far as 32 km downstream of the city center, which could pose health problems to users. The situation is similar in other main cities of Ghana like Accra and Tamale. High levels of faecal contamination are mainly due to inadequate sanitation facilities in the city which leads to poor sanitation practices like open

defecation, and broken down sanitation infrastructure. This also affects wells used for drinking water (Kyei-Baffour et al., 2005).

A seasonal variation in coliform levels and nitrate nitrogen linked to the rainy season was observed. However, the studies were not sufficiently detailed to verify these observations.

As water quality continues to deteriorate, especially in urban water bodies, it is pertinent to counteract and improve the situation. In view of limited private and public resources to mitigate nonpoint source pollution through improved infrastructure, educating the public about the dangers of indiscriminate solid and liquid waste disposal should be institutionalised and not depend on projects. The target group should include school children as successfully demonstrated by McGregor et al. (2006).