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Microbial and metal water quality in rain catchments compared with traditional drinking water sources in the East Sepik Province, Papua New Guinea

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In Papua New Guinea, a significant portion of morbidity and mortality is attributed to water-borne diseases. To reduce incidence of disease, communities and non-governmental organizations have installed rain catchments to provide drinking water of improved quality. However, little work has been done to determine whether these rain catchments provide drinking water of better quality than traditional drinking water sources, and if morbidity is decreased in villages with rain catchments. The specific aim of this study was to evaluate the quality of water produced by rain catchments in comparison with traditional drinking water sources in rural villages in the East Sepik Province. Fifty-four water sources in 22 villages were evaluated for enterococci and Escherichia coli densities as well as 14 health-relevant metals. In addition, we examined how the prevalence of diarrhoeal illness in villages relates to the type of primary drinking water source. The majority of tested metals were below World Health Organization safety limits. Catchment water sources had lower enterococci and E. coli than other water sources. Individuals in villages using Sepik River water as their primary water source had significantly higher incidence of diarrhoea than those primarily using other water sources (streams, dug wells and catchments).
Key words | diarrhoeal illness, microbial water quality, Papua New Guinea, rain catchments

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1. INTRODUCTION

-U-5 mortality in PNG=73/1000 (52nd/194 countries) in 2006 (UNICEF 2008).
-Diarrhoea 15% of u-5 mortality in 2000-2003 (WHO, 2006).
- Common pathogens in PNG: rotavirus, *Shigella, Cryptosporidium parvum, Campylobacter* and enteropathogenic *Escherichia coli* (Howard et al. 2000): water-borne diseases

-“Access to water supply service” =20 litres/person/day within 1 km from residence (WHO/UNICEF 2006); no fecal contamination should be expected.

- Coverage: 88% Urban PNG and 32% in rural PNG

-Water source: (1) Stream, (2) Well, (3) Sepik River, (4) Catchment

(1)(2)(3): risk of fecal contamination, risk of chemical contamination
(4): free from risk? (e.g., Salmonella outbreak, Taylor et al. 2000)

NGOs projects to implement water tank to communities: 8000 liter tank, a part of the cost was subsidized. Over 200 tanks (25 years)

The aims are: (1) to test the hypothesis that water quality (as measured using faecal indicator bacteria and metals) is superior in rain catchments compared with other traditional drinking water sources; and (2) to test the hypothesis that prevalence of diarrhoeal illness is lower in villages that have rain catchments.

2. Materials and Methods

-22 villages (Figure 1), July 2006 (dry season)
-water samples: 15 catchments, 25 Sepiks, 9 streams, 5 wells = 54 samples in total

-test: (A) enterococci and *E. coli* (fecal indicator bacteria)
and (B) metals and metalloids (silver, aluminium, arsenic, calcium, cadmium, chromium, copper, iron, mercury, magnesium, nickel, phosphorus, selenium and zinc) by ICP-OES (IRIS model; Thermo Jarrell Ash, Franklin, Massachusetts) with a 10% accuracy range.

-diarrhoea health data for 16 villages and their main source of water

3. RESULTS

3-1. Comparison of mEI agar paerformance at two temperatures: Figure 2 –OK

3-2. Microbiological quality of drinking water sources

Fig 3: Enterpcocci: Catchment<Stream, Well, Sepik, Stream<Sepik (K-W test)
E.coli: Catchment < Sepik (K-W test)

Fig 4 and Table 1: Catchment water is relatively safe, but not absolutely

3-3. Metal analysis: Fe 100%Sepik, 60% well >EPA threshold, Ag 94% >EPA

3-4. Health data

Water source * %diarrhoea patients of all patients (P=0.007); Sepik was the worst.

4. Discussion

Summary of findings:

(1) Rain catchments have lower enterococci and E. coli levels compared with other traditional water sources (Fig 3/4)

(2) Only rain catchments had no sources classified as poor using both microbial indicators to assess quality (Table 1).

(3) E. coli levels were significantly lower in the middle of the Sepik River compared with the bank. (data not summarized in table/figure)

(4) Of the 14 tested health-relevant metals, only iron and silver measured above the United States Environmental Protection Agency recommended drinking water limits. These are secondary metal measures relevant to water taste rather than health (Table 2).

(5) Individuals in villages relying primarily on Sepik River water for drinking water reported significantly higher incidence of diarrhoea than those using primarily other water sources (Table 3).

What catchment water was contaminated with *E. coli?*

(A) *The tropics may have natural reservoirs of E. coli, confounding the results of using E. coli and enterococci to assess water quality (Fujioka et al. 1988; Hazen 1988; Rivera et al. 1988;*

Hardina & Fujioka 1991; Fujioka et al. 1999). "Naturally occurring fecal coliforms (the genera Escherichia and Klebsiella) have been isolated from pristine sites and from sites where there was no apparent fecal contamination (Tranzos, 1991).

(B) Poor maintenance of catchment: two catchments=broken screen, one catchment=stone, sticks, and debris on the roof ==maintenance is important

Critical resources for our survival: food and water

Water catchment: impact on human ecosystem