"Is it Safe to Drink the Water": Water Quality and the Hotel Industry in Fiji

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Introduction

We are all aware of the important of the hotel industry to the economy of Fiji. Its continued growth will depend in the long term on the quality of the visitors' experience. Critical factors in this are a healthy stay and a pleasant environment surrounding the hotel. In both of these key areas members of your society play an important role in maintaining water quality which will ensure public health and the health of the environment. In recent years the Analytical Laboratory of the Institute of Applied Sciences at the University of the South Pacific has developed partnerships with a number of hotels to help them ensure the quality of their water (and food). With the expected passage of Fiji's Sustainable Development Bill there will be legal as well as economic and moral requirements to achieve water quality standards. Thoughtful managers are already working in anticipation of these new regulations to assess their water quality.

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In this paper the requirements for safe waters of different types will be discussed together with the common water pollutants and their analysis. Classical methods will be presented as well as emerging methods that engineers may be encountering in the near future. A special emphasis will be given on how analytical laboratories ensure the quality of their results and how engineers can help assess this quality.

Classification of Water and Pollutants

For purposes of regulation water is usually classified as coastal (marine), fresh and groundwater. Within each of these divisions there are three classes based on the use to be protected ranging from most protected (drinking water/important pristine ocean) to least protected (harbours, industrial and commercial areas). These are the divisions in the original drafts of the Sustainable Development Bill. The current approach is to pass enabling legislation and then Codes of Environment Practice for use by a facility or class of facility. These Codes of Environmental Practice will likely have similar water quality regulations as in earlier drafts but will be more flexible to revision.

Requirements for all waters include :

- free of visible materials, including oil and grease
- free of materials causing turbidity
- free of material causing objectionable colour or odour
- free of materials that induce undesirable aquatic life or degrade the indigenous biota
- free of toxic or dangerous materials

All of the above refer to materials attributable to human activities. For all but the lowest class of waters :

- free of objectionable taste

A number of other more specific criteria for water quality are identified which must be analysed by a competent laboratory. These include :

a)	microbiological	-	present of faecal coliforms or *E. coli* above certain levels
b)	pH	-	acidity or basicity at certain levels
c)	nutrients	-	nitrogen and phosphorus in appropriate ratio and concentrations
d)	dissolved oxygen	-	within 25% of natural conditions
e)	temperature	-	within 0.9°C of natural conditions
f)	toxic substance	-	petroleum products, heavy metals, pesticides, radioactive substances

The exact values vary depending on the usage of the water and are available from the Environment Department or the author. Common analysis performed for hotels are microbiological status of drinking water, ice, pool water and swimming beaches as well as total dissolved solids, biological oxygen demand, nutrients (phosphate, nitrate, ammonia, total N and total P) and pH for effluents.

Methods of Analysis

For microbiological determinations samples of different concentrations are placed on nutrient plates that are known to support growth of the given microorganism. The amount of colonies growing is checked periodically. A blank plate is also run with no sample added. The proposed Fiji law allows a plate count of 70 per 100 ml although WHO standards allow no faecal

coliforms for drinking water. These easily measured microbes indicate the likelihood of the presence of other disease-causing pathogens.

In general results from analyses in Fiji are good for water but less so when things are handled (food/ice). Problem periods occur after natural disasters. Many swimming beaches have high microbe counts.

Total suspended solids will add turbidity to water and are measured by filtering and weighing the suspended solids. No limits exist in the proposed Fiji law, levels below 30 mg/L are accepted overseas. Biological oxygen demand is a measure of the amount of organic material present. This uses up oxygen, which can be especially damaging for the environment in enclosed waters with long interchange times. The value is determined by measuring the amount of dissolved oxygen in a sample kept in a regulated environment over 5 days. A level of below 20 mg/L is the overseas standard for treated effluent.

Temperature and pH are measured by instruments calibrated over the range of measurement and are generally not a problem to measure or in differing from accepted levels.

One of the most critical of environmental pollutants is the nutrients containing the elements nitrogen and phosphorus. There are nutrients in terms of plant growth but such aquatic plants can overwhelm the environment and cause a dead environment when the "blooms" die back and use up all the dissolved oxygen in the water. High nutrient levels are also a cause of reduced growth in coral reefs as well as algal overgrowth.

The classical method of analysis of ammonia, nitrate (which contain nitrogen) and phosphate (which contains phosphorus) all involve reactions

with other chemicals to form characteristic colours. The more intense the colour, the higher the level of nutrient. The colour intensity is quantitatively measured in a colourimeter and compared with values for a range of known concentrations, which should form a straight line (Figure 1). A value is also determined of the reagents themselves and the sample without the reagent to ensure there is no colour contribution from these (blanks).

Nitrogen compounds generally occur in their fully oxidised form, nitrate (NO_3^-) or fully reduced form, ammonia (NH_3). A common source of the former is fertiliser and of the latter is animal waste. Total nitrogen is the sum of all nitrogen containing materials and is determined by reducing them all to NH_3 and then quantifying. For total phosphorus analysis all phosphorus species are oxidised to phosphate, which is usually the predominant species anyway, which then undergoes colour development.

In general colour reactions are being replaced by other superior methods in analytical chemistry. Although the colour formation works well for pure analytes actual biological samples can often contain other substances that enhance or diminish the intensity of the colour development. Great care also needs to be taken to avoid contamination and ensure that colour development (e.g. the exact time of addition of reagents) is identical for each sample. The advantage of these methods is they require inexpensive instruments and can detect low levels of nutrient.

Modern analysis is based on chromatography techniques, in which each component of a complex mixture is separated by a column and quantified. A triangular peak is made when it leaves the column and passes through a detector (Figure 2). The size of the triangular peak determines the amount of material, again compared to peak size of known injected amounts.

The best method of separating individual nutrients is called high precision ion chromatography (HPIC). Unfortunately the required machinery costs about F$50,000. The University has one such machines and the methods to separate nutrients of interest have been developed. Currently a research program to compare results from the classical methods with HPIC is being developed. If successful the possibility of doing routine nutrient analyses by HPIC will be studied.

Newer techniques such as analyses of specific nutrients by fibre optics or flow injection analysis are also being studied by chemists at USP.

Quality Assurance

As a paying customer to an analytical laboratory you have the right to enquire what kind of quality assurance the laboratory undertakes to ensure the accuracy of the data provided to you. Any laboratory that will not provide this should not be used. The quality assurance protocols for a laboratory can be evaluated by an outside authority and lab accreditation given. The IAS laboratory is currently in the midst of an accreditation process.

Common measures undertaken in laboratories to ensure accurate results are :

- duplicate analyses - two batches of the same sample are analysed separately (results should agree within 10%)
- spiking (recovery) - adding a known amount of an analyte to the sample (e.g. a sample that gives a value of 1 mg/L should give a value of 3 mg/L if 2 mg extra are added). This shows that the analyte is not lost during any of the processing
- method comparison - a sample can be analysed by two different accepted methods

- blanks - discussed on page 4
- in-house standard - a material whose value has been established is analysed along with samples
- proficiency exercises - lab is given a sample to analyse and its results compared to other high quality laboratories

There is some quality assurance you as the engineer can undertake. From experience you often have a sense of what likely values are and should be suspect of widely different values (if these are detected in the laboratory usually the sample is reanalysed). Other logical considerations can be used such as expecting post-treatment effluent levels to be lower than pre-treatment ones. Often there are results for which internal comparison is possible. For example, total P should be greater than phosphate and total N should be greater than either ammonia or nitrate or even the sum thereof. Doing these comparisons must be done on a molar basis, an equivalent concentration of 1 mmole P/l and 1 mmole PO_4/l will be 31 mg/l P and 95 mg/l phosphate, respectively.

One thing you should be aware of is that no laboratory will always get the correct value. Most of you will be surprised that in check sample exercises with Western European laboratories, for any analyses 10 - 35% of the laboratories produce unsatisfactory results. A good quality assurance program merely lessens the chance that a bad result will occur and be undetected. Therefore any questionable result should be discussed with the laboratory in a professional, non-judgmental way. I strongly believe in the ability of local laboratories to do high quality work. Our laboratory over the last ten years in food nutrient analysis has developed into a world-recognised expert laboratory. More recently we have been accepted as a expert laboratory in kava lactone analysis and are analysing a number of overseas samples.

Development of such quality requires regular performance of the analyses and we look forward to expanding the number of partnerships within the hotel industry to help develop over laboratory as a centre of quality in water analysis, which will help you as engineers ensure that you are providing personal and environmental health to the people of Fiji and our visitors from abroad.

09:31:10 S1006 160.00 0.9036

PO_4^{3-} Calibration Graph. - Figure 1

Z: TP; absc 0.0- 200.0; pts 501; int 0.40; ord 0.0000-1.1390; A
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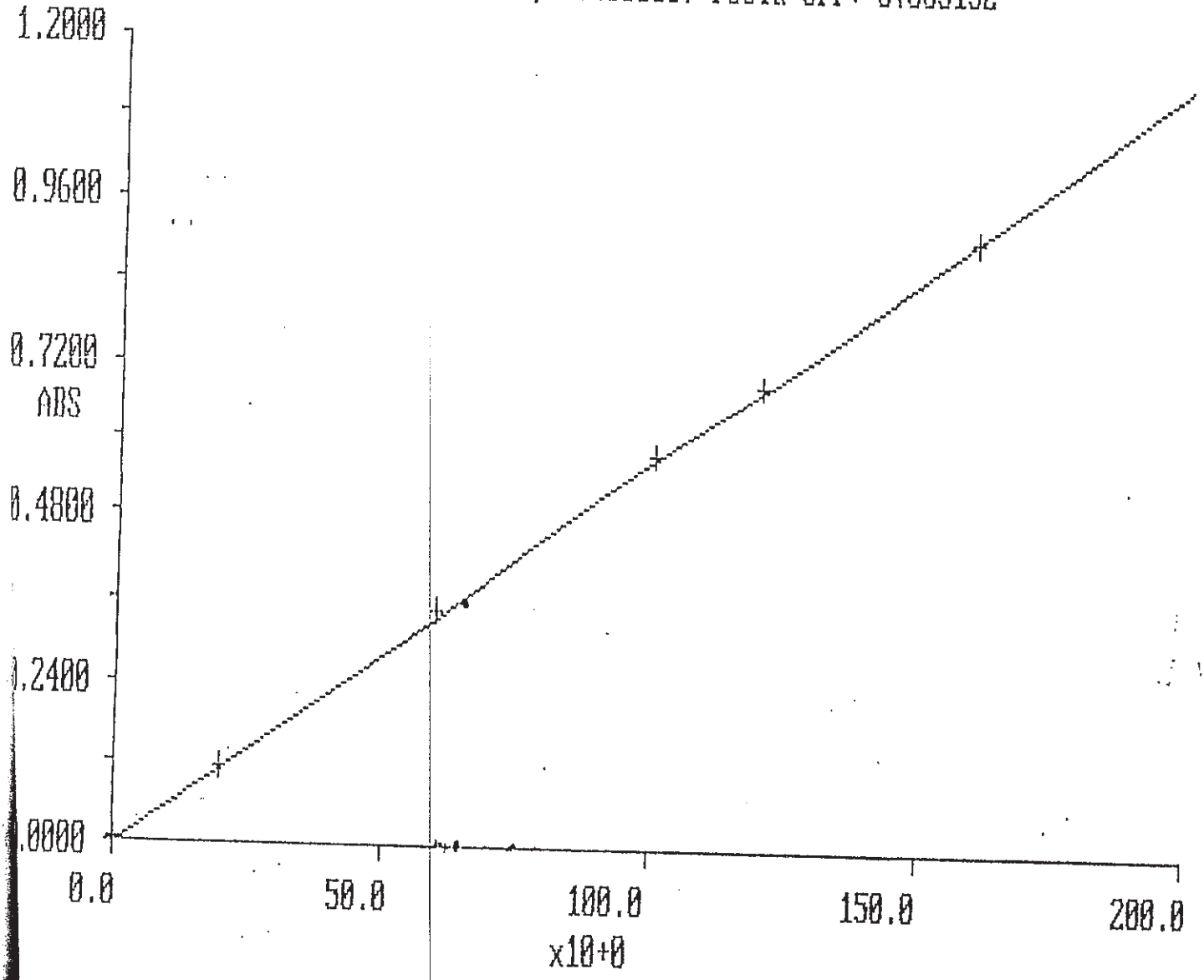

Figure 2

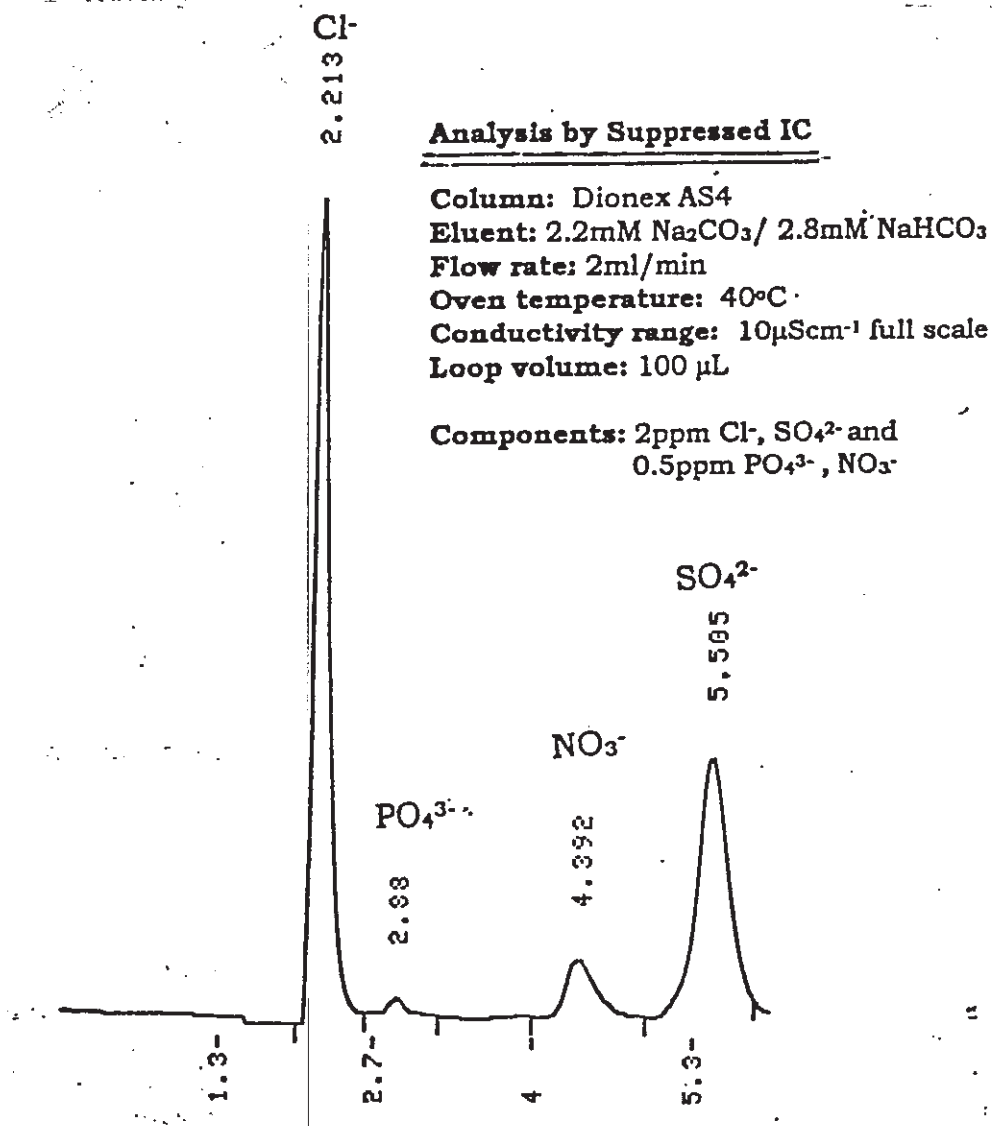

Fig. 4.3 is the chromatogram of a composite standard containing the anions Cl^-, PO_4^{3-}, NO^{3-} and SO_4^{2-}