A General Survey of Nitrate-Nitrogen Levels in Well-water under Different Landuses

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ABSTRAK

Satu tinjaun umum mengenai aras NO_3^--N dalam air perigi telah dijalankan di empat kawasan yang berlainan bentuk gunatanahnya. Empat kawasan yang dipilih ialah kawasan pertanian dengan ternakan lembu, kawasan hutan, kawasan bandar dan kawasan pertanian sahaja. Sampel air diambil dari 22 perigi yang terdapat dalam kawasan tersebut dan kandungan NO_3^--N dianalisakan. Hasil dari data yang didapati di lapangan dan ujian statistik menunjukkan aras NO_3^--N air perigi dari kawasan gunatanah yang berlainan kecuali kawasan pertanian + ternakan, menunjukkan perbezaan yang ketara di mana kawasan pertanian mempunyai aras NO_3^--N yang tertinggi diikuti oleh kawasan bandar dan hutan.

ABSTRACT

A general survey on NO_3^--N levels in well-water under different landuses was conducted. Four areas were selected to represent different landuses namely mixed farming (crop and animal production), forest, urban, and crop production only. Water samples from a total of 22 wells in the selected areas were collected and analysed for NO_3^--N. The field and statistical data showed that the differences in NO_3^--N levels in well-water from different landuses were significant except for agriculture + animal farming. The highest NO_3^--N level was observed in agricultural areas followed by urban and forested areas.

INTRODUCTION

Agriculture is important to the Malaysian economy. Lately there has been substantial developments in the cultivation of rubber, oil palm, cocoa, fruits and vegetables. These developments in agriculture have also resulted in increased use of commercial fertilizers, herbicides and insecticides in an effort to obtain higher yields.

The increase in usage of chemicals in agricultural activities has raised questions regarding chemical pollution of groundwater, especially by plant nutrients, for example, nitrate-nitrogen (NO_3^--N). Previous studies have indicated that most of the NO_3^--N in groundwater is associated with the use of fertilizers (Smith *et al.* 1971; Gentzsch *et al.* 1974; Lund *et al.* 1974; Meek *et al.* 1974; Gray and Jones 1980; Khanif *et al.* 1983; Bergstorm 1987). Besides fertilizers, there are also other contributing factors such as rainfall, natural processes (hydrologic, geologic and biological) (Tanji 1979), and industrial and domestic wastes (Tanji 1979; Gray and Jones 1980).

Potable water with high concentrations of NO_3^--N is hazardous to health especially for young infants. The maximum concentration of NO_3^--N for potable water should not exceed 10 mg/l. Higher NO_3^--N concentrations can cause a disease called methaemoglobinemia in infants (Bouwer 1978).

There is no doubt that the use of chemicals in modern agricultural activities has resulted in increased productivity but there is also the need to examine its effect on the quality of our water resources. In Malaysia, little attention has been given to the research aspects of nutrient pollution. This study seeks to provide basic information in

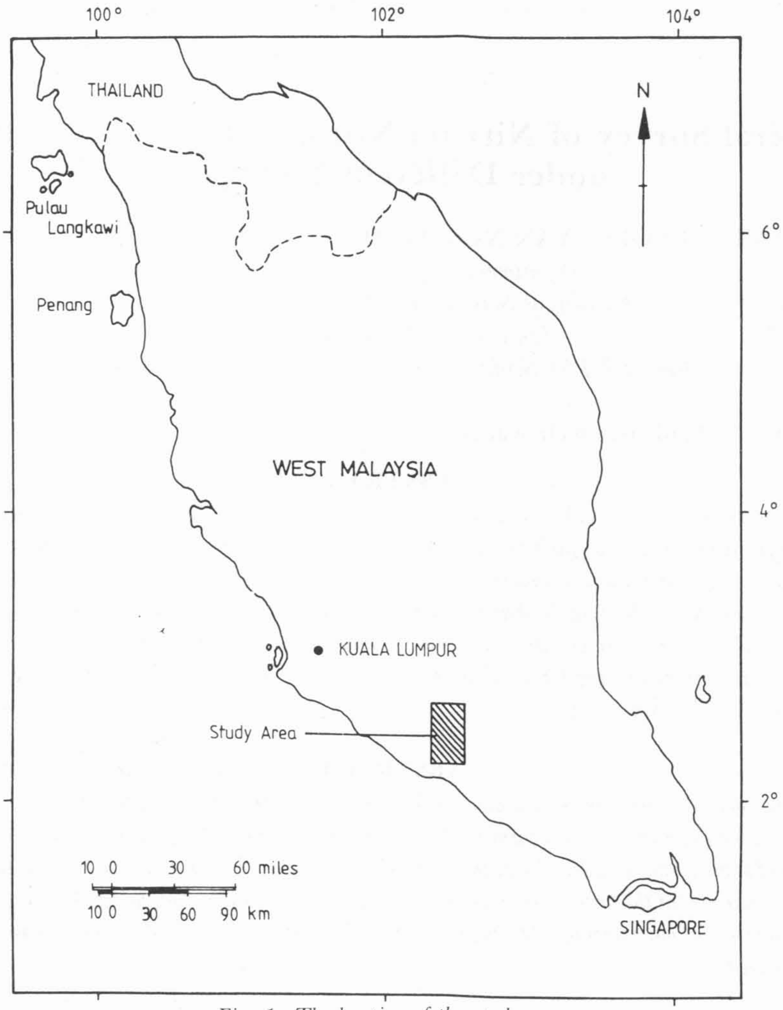

Fig. 1: The location of the study area.

order to have a better understanding and awareness of nutrient pollution in groundwater with respect to landuse.

Site Information

The areas studied include three locations in the Rembau district of Negeri Sembilan, and one in the Alor Gajah district of Malacca *(Figures 1* and *2).* Each area represents a different landuse:

a. Taman Sri Kendong (A1) in Alor Gajah has an area of 1.2 km². This area was formerly completely under rubber. Landuses include animal farming with pasture land, rubber and fruit plantation, and fruits and flower nurseries.

b. Kg. Pulau Bintongan (A2) in Rembau is a forested area. The people in this area depend upon forest products such as fruits, bamboo and rattan for their income.

c. Rembau (A3) is a small town with a population of 1500 and an area of 1.5 km² and is classified as urban landuse. This area contains Government buildings, housing estates, schools, a hospital, petrol station and shops.

d. Chembong (A4) in Rembau has an area of 1.2 km² with agriculture as the main landuse activity. This area has an Agricultural Training School, a Vocational Agricultural School, oil palm nurseries and experimental plots for vegetables and fruits.

The soil series in all the selected areas is Renggam with granite as parent material. The

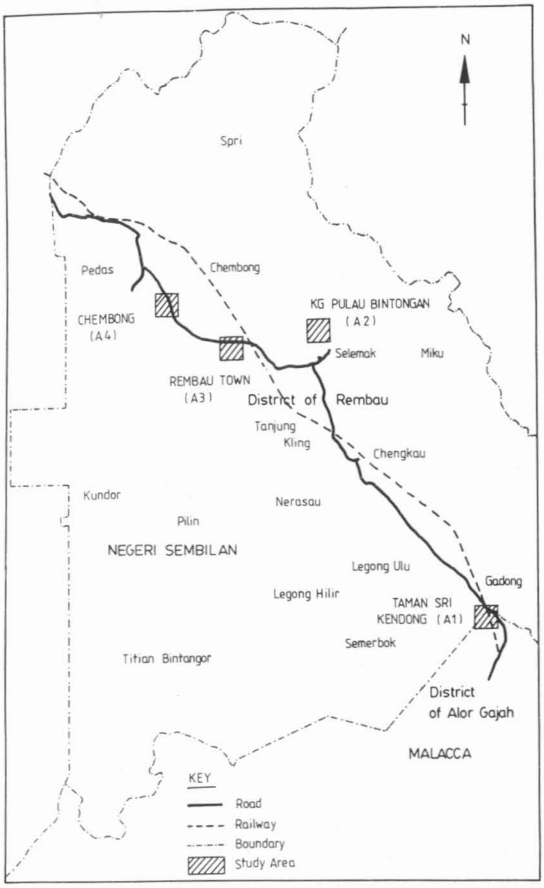

Fig. 2: The location of the four selected sites.

water table is greater than 1.5 m from the ground surface and the soil texture is maily sandy clay loam at 10 to 120 cm depth (Malaysian Geological Department 1974).

The climate is classified as tropical humid climate with a yearly average rainfall of 2000 mm. The amount of rainfall during the months of October, November and December 1985 were 245, 326 and 190 mm respectively.

Among existing wells within the selected areas, 22 wells were selected for the purpose of this study. The number of wells selected in each area depends on availability and accessibility, and the distribution for A1, A2, A3 and A4 are 7, 7, 5 and 3 wells respectively. All the wells in A1, A3 and A4 are covered with cement slabs and are pump-driven with depths ranging from 10 to 30 m for A1, and 10 to 20 m for A3 and A4. All of the wells in A2 are of the open type and manually operated with depths ranging from 5 to 10 m. All the wells selected for this survey are located in individual house compounds.

MATERIALS AND METHODS

Water samples from the selected wells were obtained direct from the tap supplied by the pump except for the wells in A2 where sampling was done manually. Each water sample was poured into a clean plastic bottle (250 ml capacity) and 0.5 ml of concentrated sulphuric acid was added to inhibit the bacterial activities. The samples were stored in an ice box and transported back to the laboratory (80 km away) for analysis on the same day. The well waters were sampled six times from October to December 1985. During each visit, a total of 66 samples were taken with replicates of 3 samples per well. Sampling was carried out in the morning and time taken was about three hours to cover all areas.

The brucine-sulphate method was used to analyse NO_3^--N concentrations in water using a spectrophotometer (Perkin-Elmer 55E) at 410 nm (US EPA, 1979).

The data obtained was analysed statistically using the SAS package. The variation over time (dates of sampling) represents the sampling variation for the testing of differences among landuses for NO_3^--N levels. The true experimental error was estimated by averaging the sampling dates of each well and landuse, and this procedure takes into account the unequal number of wells sampled for each landuse. The experimental error derived from the variation among wells within landuse is the appropriate error to test for the landuse effects. The homogeneity of the error variances in the treatments (landuse) was tested before conducting an analysis of variance.

RESULTS AND DISCUSSION

Table 1 shows the mean concentrations of NO_3^--N in well water in each well under different landuses averaged over six sampling dates. Table 2 shows the residual of the homogeneity of variances analysis. The Chi-Square test for homogeneity of error variances showed that the variance among the four landuses were not homogeneous (Chi-Square = 28.8, probability < 0.0001). The deletion of the variance from landuse of Agriculture + Animal Farming (A1) gave a Chi-Square of 1.12, which has a probability of between 0.5 to 0.75. Hence the three other

TABLE 1

NO_3^--N levels (mg/l) in well water averaged over 6 sampling dates.

	Well No.							
Landuse	1	2	3	4	5	6	7	Mean
A1	7.11	3.33	2.56	1.06	0.78	1.06	1.95	2.55
A2	0.99	0.23	0.73	0.96	0.29	0.47	0.27	0.56
A3	1.51	0.31	0.40	2.60	2.11	-	-	1.38
A4	4.13	2.78	1.84	-	-	-	-	2.91

landuses (A2, A3 and A4) were grouped together in a combined analysis of variance.

The results of the combined analysis of variance with three landuses (A2, A3 and A4) are shown in Table 3. In this analysis, the effects of landuse was tested with the wells within landuse component (WELL-NO (LANDUSE)). The analysis showed that the experimental error has a magnitude of 3.71099. The mean square error (MSE) for the landuse of Agriculture + Animal Farming (A1) was 29.3327, with 7 degrees of freedom and mean NO_3^--N of 2.25 mg/l.

TABLE 2

Residual of the homogeneity of variances analysis

Landuse	Error MS	Error DF
A1	0.2595	30
A2	0.0446	30
A3	0.0672	20
A4	0.0450	20

TABLE 3

The combined analysis of variance for A2, A3 and A4

Source	DF	TYPEIII SS
Landuse	2	69.9889
Well-No (Landuse)	12	44.5319
Dates	5	0.9369
Landuse x Dates	10	0.6880

LSD

Alpha = 0.05 DF = 12 MSE = 3.71099

Grouping	Mean	N	Landuse
a	2.9139	18	A4
b	1.3843	30	A3
b	0.5617	42	A2

The t-test was used to compare the largest mean difference between two landuses, viz. Agriculture + Animal Farming (A1) and Forest (A2) with unequal variance at $t = 2.24$. In order to be significant at 5% level, with 7 degrees of freedom, the t value should be $\geqslant 2.365$. With 12 degrees of freedom, the t value should be $\geqslant 2.179$. The results of the t-test showed that differences in the NO_3^--N levels between A2 and A1 was barely significant at 5% and it also showed that landuses with NO_3^--N higher than 0.5617 are not significantly different from that in A1.

The statistical analysis showed that the type of landuse plays an important role in changing the chemistry of well-water (in particular, NO_3^--N) and it is only true for A2, A3 and A4. The results indicate that agricultural activities contribute towards the increasing levels of NO_3^--N in well-water. This may occur through the process of leaching of fertilizers followed by subsurface flow of groundwater flow towards the wells. Urban areas contribute less compared to agricultural areas. It is worth noting that the forested (no fertilizer input) has the lowest NO_3^--N levels in the well-water. From the results, it can be seen that there was no significant difference between the NO_3^--N levels in A1 and other areas and this may be due to the degree of intensity of agricultural activities in A1 which is less than that in A4.

CONCLUSION

It may be concluded that NO_3^--N concentrations in well water located in agricultural areas are significantly different from urban and forested areas but not to Agricultural + Animal Farming areas. The addition of fertilizers resulted in increased NO_3^--N content in the well water.

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