A PRELIMINARY STUDY OF NITRATE CONCENTRATION IN SOIL AND WELL WATERS FROM AGRICULTURAL AND NON-AGRICULTURAL LANDS

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Abstract: A preliminary study has been carried to determine the nitrate distribution in soils and well waters located in Batu Rakit – Kuala Nerus district of Terengganu. Main objective of the study is to evaluate the impact of agricultural activities on levels of nitrate in the study area. A total of four locations were chosen covering four different soil types. At each location, soils were sampled from two sites, each representing an agricultural and non-agricultural site. Well water was also collected at two sites per sampling location representing agricultural and non-agricultural sites. Nitrate content in soil and water was determined using ion chromatography. In addition, the pH of soils and well waters were also determined using pre-calibrated pH meter in the laboratory and at the site, respectively. Results obtained suggest that agricultural sites exhibit a marginally higher nitrate concentration than the non-agricultural sites but no clear trend with depth could be observed for both types of land-use. In the case of soil pH, although results obtained suggest some variations in soil pH with depth particularly in the cultivated land, statistically, these variations are insignificant. Nonetheless, comparison of the data suggests that types of soils could to some extent play a role in controlling the concentrations of nitrate and pH values in soils. However, the trend in well water is not obvious where no clear influence of agricultural activities and soil types could be discerned on the levels of nitrate and pH in the water.

Keywords: Nitrate, Soils, Well water, Agricultural land, Non-agricultural land

INTRODUCTION

Nitrate is introduced into the agricultural setting through the use of fertiliser, the accumulation and application of animal manure and from septic sytems [1]. It is reported that a major mechanism for loss of nitrogen in humid climates from soils is leaching to groundwater as the soluble and mobile anion nitrate [2]. The leaching of nitrate into the aquifers poses high risk of groundwater contamination, which is the primary source of drinking water for rural residents. Studies have shown that wells that were shallow, old, dug, located in permeable soils, or within close proximity to cropland and feedlots were more vulnerable to nitrate contamination [3,4]. The occurrence of nitrate in groundwater is a significant public health issue that has received considerable attention over the years. Excessive intake of nitrate in infants has been linked to methemoglobinemia [5] and rates of mortality from gastric and prostate cancer [6]. Use of wells for potable purposes is still prevalent in rural areas of Terengganu. Wells located in areas close to cultivated land could potentially be vulnerable to nitrate infiltration, thus posing health concern to its users. This preliminary study is conducted to determine the level of nitrate in soils and wells of an agricultural land and adjacent non-agricultural land and thus assess the degree of impact of agricultural activities on the levels of nitrate in these soils and wells.

MATERIAL AND METHODS

Study Area

Four areas within the Batu Rakit - Kuala Nerus district, Terengganu were chosen for this study. Figure 1 shows the location of the study area; the four sites viz. Kg Ru Tapai (station code RT), Kg Sungai Mas (station code SM), Kg Bukit Berangan (station code BB) and Kg Pondok Lalang (station code PL) were

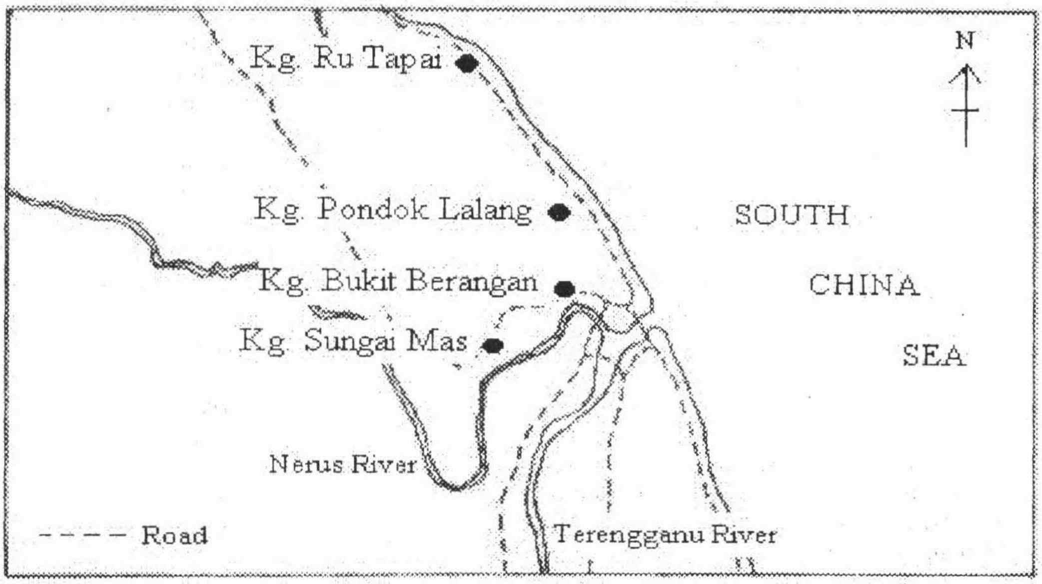

Figure 1: Location of the sampling area

chosen based on the differences in their soil classification [7] that is sandy, lateritic, peaty and clayey soil, respectively. Within each study area, two sites were chosen for soil and well water collection, one from a cultivated land to represent an agricultural area and the other from a housing area with no visible agricultural activities to represent a non-agricultural land. These two sites are assumed to have similar soil type. Main cultivation at the four agricultural sites is vegetable crops and these sites have been under cultivation for over seven years. The wells chosen for water sampling are used for irrigation and domestic purposes.

Soil and Water Sampling

Soils from each site were sampled at two depths, viz. 0-10 cm (surface soil) and 30-40 cm (bottom soil) using metal spade or hoe and each soil sample was wrapped in a clean plastic bag and transported to the laboratory where it was then air-dried and sieved. Only soils fractions < 2 mm were used in this study. Well water from open wells were collected using a metal bucket or by using Van Dorn sampler. Water samples were kept in a 1 L pre-cleaned PE bottles and transported cool to the laboratory. Once in the laboratory, these samples were immediately filtered using 0.45 μm filter paper and then kept in the freezer until analysis. Soil and water sampling were carried out three times over the September to November period.

Analytical Procedure

Nitrate in soil is extracted from the soil matrix using 0.01M $CaSO_4$ solutions (1:10 soil to $CaSO_4$ ratio). The supernatant solution is then filtered and the filtrate is analysed for nitrate using an ion chromatography [8]. Nitrate in well water is measured directly using similar method. Soil pH was determined using glass electrode in a 1:5 soil to water ratio and pH of well water was measured in-situ using a pre-calibrated glass electrode.

RESULTS AND DISCUSSIONS

Table 1 shows the results obtained for soils whilst Table 2 present the results obtained for well water from agricultural and non-agricultural sites.

Soil

In general, results of the analysis indicate that pH of soils in the study areas were in acidic range. Lowest pH values found in Kg Bukit Berangan area; surface soil pH for agricultural and non-agricultural site was found to range from 3.71 to 4.35 and 3.79 - 4.11, respectively while bottom soil pH for agricultural and non- agricultural site was in the range of 3.64 - 4.06 and 3.63 – 5.54, respectively. Average pH value for surface and bottom depth in the agricultural site was calculated to be 3.96 and 3.81, respectively whilst in the non-agricultural site, average was found to be 3.96 and 4.25, respectively. Peat soils is known to be acidic in nature, thus it is not surprising that sites in Kg. Bukit Berangan exhibit a much lower pH values than other sites. Comparison between depth and sites showed that there are some variations in soil pH particularly in the agricultural land, which exhibited, on average, a decreasing trend with depths; however, ANOVA test showed that these variations is insignificant between sites albeit agricultural and non-agricultural land as well as depths.

Overall, the level of nitrate in soils was found to range from 0.29 to 7.42 ppm for agricultural sites and from 0.20 to 7.28 ppm for non-agricultural sites. Highest levels of nitrate were observed in lateritic soils of Kg Sungai Mas for both types of land-use. Comparison of data presented in the table also show that in general, slightly higher nitrate concentration is observed in the agricultural soils than the non-agricultural soils with the overall, i.e. combining surface and bottom depths values, mean value of 2.18 ppm and 1.42 ppm, respectively. In addition, it could be observed that soil types to some extent can influence the concentration of nitrates in soil. Calculation of mean value for surface and bottom depths for each type of land-use also revealed marginally higher averages were obtained for the agricultural land compared to the non-agricultural land. Mean value for surface and bottom depths for the agricultural land was found to be 2.31 and 2.05 ppm, respectively compared to the non-agricultural land which gave a value of 1.46 and 1.38 ppm for surface and bottom depth, respectively. However, F-test indicates that there is no significant difference in mean value of nitrate in surface and bottom depth for both land-use types.

Well water

With the exception of a well sited in a agricultural land in Kg Rhu Tapai (sandy soils) which shows marginally lower pH range (4.72 – 5.20) and mean (4.91$\pm$0.26), pH of well waters for the remaining sites exhibit values in the range of 5.07 to 6.72 with average values ranging from 5.75 $\pm$ 0.60 to 6.27 $\pm$ 0.46. ANOVA test however showed no significant differences between sites.

Nitrate levels in well water sited in agricultural land showed average values in the range of 0.28 - 4.21 ppm with the well located in Kg Rhu Tapai exhibited the highest average value, followed by the well in Kg Pondok Lalang, Bukit Berangan and Sungai Mas, respectively. Interestingly, higher average value of nitrate were observed in wells sited in a residential area (i.e. non-agricultural area) ranging from 0.21 to 9.30 ppm with the well located in Kg Pondok Lalang exhibited the highest value followed by Bukit Berangan, Sungai Mas and Rhu Tapai. Although nitrate is present in the well water, the levels recorded are generally still within the limit recommended by the WHO for this parameter (45 mg/L) [9].

Figure 2 compares the trend between mean nitrate in well waters and soils under different land-use. No clear correlation between nitrate in soils and well waters could be discerned from this comparison, suggesting minimal impact of agricultural activities on the levels of nitrate in the well-water; the present result might suggest, if any, some influence of domestic septic system and domestic discharge to the quality of well water in the non-agricultural sites for usually in the rural areas, well is located in close proximity to the house with the septic tank normally located within a short distance from the well. In addition, domestic wastes are commonly discharge directly onto the soils and subsequently, wastewater accumulates on the ground and will slowly percolate into the ground.

Table 1: pH and nitrate values for soil

Station Code	Agricultural area				Non-agricultural area			
	pH		Nitrate (ppm)		pH		Nitrate (ppm)	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
PL (surface)	3.31-5.81	4.58 ± 0.87	0.52-1.30	0.99 ± 0.42	3.44-4.41	3.89 ± 0.37	0.20-3.48	1.44 ± 1.78
PL (bottom)	3.71-4.67	4.30 ± 0.35	1.03-1.40	1.22 ± 0.19	3.48-4.26	3.89 ± 0.29	0.20-1.61	0.97 ± 0.71
BB (surface)	3.71-4.35	3.96 ± 0.24	1.78-2.27	2.17 ± 0.35	3.79-4.11	3.96 ± 0.13	0.29-1.46	0.97 ± 0.61
BB (bottom)	3.64-4.06	3.81 ± 0.17	0.51-1.56	0.89 ± 0.58	3.63-5.54	4.25 ± 0.68	0.30-1.01	0.59 ± 0.37
SM (surface)	4.54-5.84	5.36 ± 0.44	2.75-7.42	5.45 ± 2.42	3.89-6.53	4.47 ± 1.02	1.40-5.23	2.81 ± 2.11
SM (bottom)	4.37-5.71	4.82 ± 0.57	4.45-6.79	5.72 ± 1.18	3.86-6.65	4.50 ± 1.05	1.63-7.28	3.58 ± 3.21
RT (surface)	4.02-4.22	4.08 ± 0.09	0.55-0.68	0.63 ± 0.07	3.34-4.95	3.99 ± 0.62	0.40-0.77	0.63 ± 0.20
RT (bottom)	3.20-4.17	3.88 ± 0.35	0.29-0.41	0.36 ± 0.06	3.61-4.50	4.02 ± 0.30	0.20-0.75	0.39 ± 0.31

Table 2: Nitrate and pH values for well water

Station Code	Agricultural area				Non-agricultural area			
	pH		Nitrate		pH		Nitrate	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
PL	5.74-6.27	5.98 ± 0.27	0.07-2.28	1.11 ± 1.11	5.55-6.20	5.91 ± 0.36	7.52-11.74	9.30 ± 2.19
BB	6.08-6.37	6.25 ± 0.15	0.07-1.14	0.44 ± 0.61	5.07-6.20	5.75 ± 0.60	6.90-7.01	6.96 ± 0.06
SM	5.81-6.72	6.27 ± 0.46	0.04-0.51	0.28 ± 0.24	6.10-6.33	6.23 ± 0.12	0.33-0.55	0.44 ± 0.11
RT	4.72-5.20	4.91 ± 0.26	2.73-6.63	4.21 ± 2.11	6.58-7.32	6.90 ± 0.38	0.17-0.25	0.21 ± 0.04

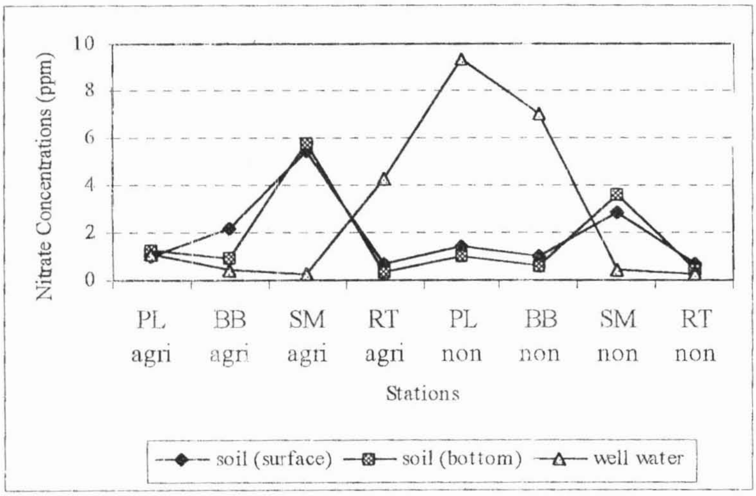

Figure 2: Comparison of mean nitrate between well waters and soils under different land-use

CONCLUSION

Results in the present study suggest that for nitrate, agricultural sites exhibit a marginally higher level than non-agricultural sites but no clear trend with depth could be observed for surface and bottom depths for both types of land-use. In the case of soil pH, although results obtained suggest some variations in soil pH with depth particularly in the agricultural land, statistically, these variations are insignificant. Nonetheless, comparison of the data suggests that types of soils could to some extent play a role in controlling the concentrations of nitrate and pH values in soils. However, the trend in well water is not obvious where no clear influence of agricultural activities and soil types could be discerned on the levels of nitrate and pH in the water. It must be conceded that there were several shortcomings in this preliminary study; firstly the sampling period (September to November) only covers what is considered a wet period thus no comparison could be made with data obtained during the drier period. Secondly, the frequency of sampling and number of sites within an area should be increase to get a better representation of the area. Finally, probably the types of agricultural activities (vegetable growing) did not require extensive input of fertilisers hence impact as a result of seven years of cultivation is not really apparent.

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