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Nitrate-Nitrogen Content of Well Water and Soil from Selected Areas in the Jaffna Peninsula

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Abstract: This paper describes the results of a study concerning the amount of nitrate present in drinking water and soil in selected locations in the Jaffna Peninsula. In several places the amount of nitrate-nitrogen is above the safe level specified in the WHO International Standard for drinking water.

1. Introduction

In the Jaffna Peninsula there is a small acreage of Paddy lands but the majority of the cultivated lands is used for agricultural activity concerned with short term crops. Water for these is obtained from wells situated close by. Drinking water is also obtained from wells. In villages,each house or a group of houses has its own well. But in the Jaffna town and coastal areas like Kayts water is supplied by the Municipality and for this purpose the water is drawn from wells in the adjoining villages — Thirunelvely and Kondavil. These villages have a reasonable agricultural activity. Over the years it has been noted that Jaffna farmers have been using increasing quantities of fertilizers and attempts have been made to study the effect of large scale use of fertilizers on the ground water and soil. One of the serious problems is the increasing levels of nitrates and nitrites in drinking water which can be hazardous. Other sources of nitrates and nitrites are animal and human urine and excreta. It is also possible that some of the other nitrogen containing compounds are oxidised to nitrites and nitrates over the years.

It is well known that nitrates and nitrites above a certain level in drinking water and soil may cause serious health problems due to their toxicity. It has been reported[10] that if the drinking water contain more than 10 ppm nitrate-nitrogen (45 ppm - nitrate), it could affect the health of infants and children. Apparently a microorganism in the gastrointestinal tract can convert nitrate into nitrite which under the biochemical conditions oxidises the Fe^{++} in haemoglobin to Fe^{+++} , producing methaemoglobin. Methaemoglobin cannot transport oxygen in the blood and the resulting oxygen deficiency produces the characteristic bluish skin colour [8,9,10]. Therefore nitrates in the water consumed by infants may give rise to methaemoglobinaemia (blue babies).

That methaemoglobinaemia is associated with high nitrate content in drinking water, was first discovered in 1945. Since that time about 2000 cases of blue babies have been reported from North America and Europe.[8]

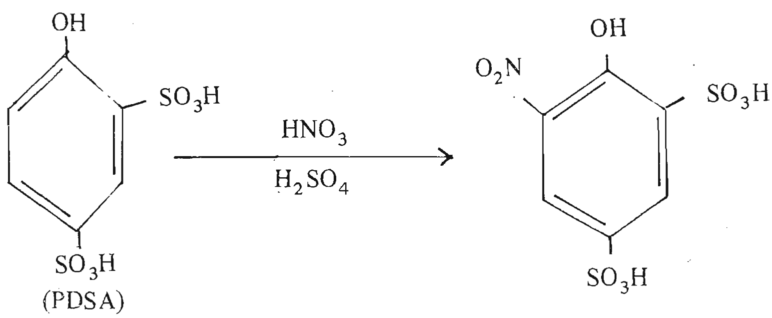
Excess of nitrate in the drinking water could also affect older children and adults. The nitrates can be converted to the nitrites which in turn can produce nitrosamines by reaction with suitable amino compounds in the body.[10] Nitrosamines are carcinogenic and hence a hazard to human health.

Increased nitrogen in the soil also may cause serious health problems because some plants such as carrots could store this excess nitrate and then reduce it partly to nitrite within itself. The nitrites could convert haemoglobin to methaemoglobin or produce nitrosamines and thus the carrots containing excess nitrate is a health hazard.[9]

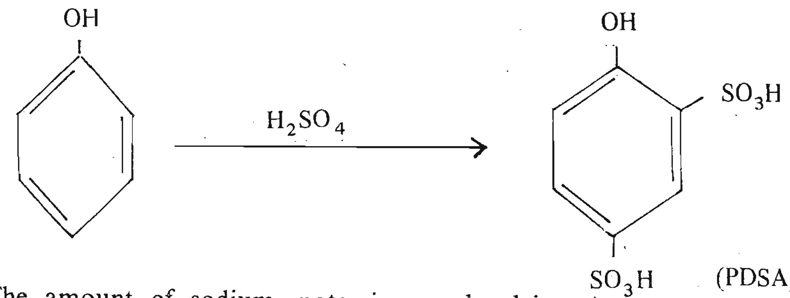
2. Experimental Methods and Materials

Several methods[3] are available for the estimation of nitrates. One method is to determine the total oxidised nitrogen and then subtracting the colorimetrically estimated value for the nitrite.[1] The alpha naphthylamine-pink colour method[1] may be employed to determine the amount of nitrite colorimetrically. Reduction of nitrate and nitrite with hydrogen generated by either iron filings in sulphuric acid or Devardas alloy in alkaline solution has been employed to estimate total oxidised nitrogen. The reduction of nitrate to nitrite could be carried out by cadmium—copper reagent[2] and α-naphthylamine-pink colour method could be used to determine the total oxidised nitrogen. (It should be noted that α-naphthylamine is carcinogenic). Another method uses 2:6 xylenol as indicator in a colorimetric determination of nitrates.

In our investigation, the nitrate-nitrogen was estimated by nitrophenol-disulphonic acid yellow colour method.[6] This method depends upon the nitration of position 6 of phenol-2,4-disulphonic acid.



Phenol-2, 4-disulphonic acid was prepared[6] by heating a mixture of phenol and conc H_2SO_4 in boiling water bath.



(PDSA)

The amount of sodium, potassium and calcium in water samples were determined immediately after collection using a Corning Model 400 flame photometer. The flame intensities for sodium were corrected for interference by calcium by the standard - addition method[5] The samples were collected in clean dry dark glass bottles with bakelite screw caps and when necessary they were stored at 0°C. The nitrate-nitrogen was determined within three days of collection.

Two litres of water samples were concentrated and made up to 25ml with distilled water in a volumetric flask. These samples were used for colorimetric determinations.

The samples for colorimetric measurements were prepared as follows:

Concentrated Water sample (25ml)
↓ Ag_2SO_4 (Shake for 15 min.)
Filtrate
↓ Shake with $Ca(OH)_2$ and $MgCO_3$
Filtrate
↓ (i) Pipette 5.0 ml (ii) Evaporate on a steam bath
Residue
↓ (i) Phenol-2, 4-disulphonic acid (ii) Add 20 ml water after 15 min
Solution
↓ NH_4OH
Alkaline solution (Yellow) (made to 100 ml with distilled wate).

Soil sample
↓ Sieved 22 - 60 mesh size 0.2% $CaSO_4$ solution
Extract
↓ Shake with Ag_2SO_4
Filtrate
↓ Shake with $Ca(OH)_2$ and $MgCO_3$
Filtrate
↓ (i) Pipette 25.0 ml (ii) Evaporate on a steam bath
Residue
↓ (i) PDSA (ii) add 20 ml water after 15 min.
Solution
↓ NH_4OH
Alkaline solution (Yellow) (made to 100 ml)

The aqueous extract of the soil or water sample was evaporated to dryness previous to determination since the reaction must be effected in the virtual absence of water. The product behaves as a nitrophenolic type indicator - it is colourless in acid and yellow when neutralised or in alkaline solution. Ammonium hydroxide was therefore used to shift the pH to the yellow range for colorimetric determination.

The optical densities of test solutions were measured in a colorimeter (Corning 252) using a 420nm filter and from the results obtained nitrate-N content was calculated using a reference graph.

Standard nitrate solution containing 10 μg nitrate-nitrogen per ml was prepared according to known procedure.[6] 5.00, 10.00, 12.00, 14.00, 16.00, 18.00, 20.00, 23.00, 25.00 and 30.00 ml aliquots of this solution were taken and subjected to identical procedure[9] as in the case of test samples and optical densities were measured.

3. Results and Discussion

3. 1 Nitrate in Soil

The results (Table I) shows that in several areas in the Jaffna Peninsula the soil samples have nitrates above the safe level. In plots where there is no cultivation, the amount of nitrate in soil adjoining the well is below 20 ppm in majority of cases. But in those plots where there is cultivation the soil adjoining the well seems to have fairly large quantity of nitrate, usually above 30 ppm. The results however are not conclusive.

3. 2 Nitrate in well water

The water samples from wells in plots where there is no cultivation have relatively low nitrate-nitrogen levels. Thus the wells in the following localities where there is no cultivation have less than 18 ppm of nitrate-nitrogen.

(i) Post Office and Hospital of the Jaffna Town
(ii) Kopay houses
(iii) Naranthanai
(iv) Karaveddy

(v) Thavady
(vi) Vannarponnai
(vii) Kokuvil
(viii) Uduvil
(ix) Irupalai
(x) Nallur
(xi) Kadduvan
(xii) Tellippalai
(xiii) Mirusuvil.

The water samples from the wells in plots where there is agricultural activity have nitrate-nitrogen levels between 20 and 50 ppm. The villages of Kondavil and Urumpirai where there is intense agricultural activity have very high nitrate-nitrogen level (30-50 ppm). Even water samples from wells in plots in these villages where there is no cultivation have more than 20 ppm of nitrate-nitrogen.

The water samples from the wells in Thirunelvely and Kondavil from which water is drawn for town supply have a high nitrate-nitrogen levels (26-33 ppm) which are about three times the safe level. Our investigations also indicate that the nitrate-nitrogen levels in the water of the wells used for town supply gradually increases year by year. Thus the nitrate-nitrogen level of Thirunelvely water supply well water increased from 15 ppm in December 1976 to about 22 ppm in December 1980 and to about 27 ppm in May 1982 (Table II). Similarly the nitrate-nitrogen level in the water sample from the town water supply well from Kondavil increased from 22 ppm in December 1976 to about 30 ppm in December 1980 and to about 34 ppm in May 1982.

It is apparent that the indiscriminate use of fertilizer is the chief reason for the rapidly increasing nitrate-nitrogen level in well water. We feel that the Jaffna farmers are using fertilizers far in excess of what is required. This conclusion is supported by the fact that the quantity of fertilizer sold in Jaffna is very large.

In certain parts of the Jaffna town area where there is no cultivation the nitrate-nitrogen level in well water approaches 20 ppm. This is probably due to inadequate sewerage disposal facilities. Also in thickly populated areas the wells are situated close to the soakage pits of the toilets and this may result in increased nitrate-nitrogen levels in well water. With increasing demand for houses, the local authorities are willing to reduce the minimum distance between the wells and septic tanks from 35 ft to about 25 ft. This could cause serious health problems in a district like Jaffna where the limestone rock is fairly close to the earth surface and hence minimum soakage and absorption is possible.

Table 1. Amount of Nitrate-Nitrogen in well water and soil and the amounts of Na, K and Ca in well water

Locality		Amount of Nitrate N in ppm in		In well water samples amount of		
		Soil*	Well Water*	Na^+/ppm*	K^+/ppm	Ca^{2+}/ppm
1. Jaffna Town (not cultivated)						
a) Post Office	i)	6.3	10.0			
	ii)	6.90	13.4			
b) Hospital	i)	8.1	14.6			
	ii)	9.1	17.7			
c) Station Road	i)	12.2	20.7			
	ii)	13.1	22.0			
d) Koddady East	i)	11.3	18.9			
	ii)	12.0	19.8			
e) Koddady West	i)	11.3	18.0			
	ii)	12.8	20.3			
2. Vannarpannai (not cultivated)	i)	3.0	12.0	161	7.4	22.8
	ii)	4.3	12.4	182	7.5	23.2
3. Nallur (not cultivated)		3.0	2.2	53	1.2	14
4. a) Kokuvil (not cultivated)		2.0	8.5	202	3.4	21
b) Kokuvil (cultivated)		2.5	18.6	—	—	—
5. a) Thavady (not cultivated)		3.1	6.7	122	2.2	22
b) Thavady (cultivated)		8.4	26.5	138	2.4	26
6. Thirunelvely area						
a) Thirunelvely water supply well		19.6	26.3	1242	5.7	30.1
b) Thirunelvely Agricultural research station		10.7	21.3	—	—	—
6. c) Farm School (cultivated)		22.3	22.1	—	—	—
d) Thirunelvely (cultivated)	i)	24.1	24.8	506	4.5	40
	ii)	21.3	23.6	454	4.2	36.5
7. Kondavil area						
a) Kondavil East Vanniasingam Veethy (cultivated)	i)	31.6	41.0	134	2.0	29
	ii)	25.6	28.5	146	2.2	25.8
	iii)	27.0	29.5	—	—	—
	iv)	28.8	32.6	—	—	—
b) Kondavil water supply well (not cultivated)		7.2	33.0	759	3.7	32
8. Irupalai (not cultivated)		5.0	6.0	851	4.0	40
9. Urumpirai (cultivated areas)						
a) Urumpirai East (samples from different wells)	i)	31.6	41.0	—	—	—
	ii)	47.0	43.0	—	—	—
	iii)	25.6	38.6	—	—	—
	iv)	38.8	39.6	—	—	—
	v)	35.0	44.4	—	—	—
	vi)	39.2	45.0	—	—	—
	vii)	53.8	48.0			
	viii)	21.3	45.6			
b) Urumpirai West	i)	310	53			
	ii)	58.8	50			

(contd.)

Table 1 (contd.)

Locality	Amount of Nitrate N in ppm in		In well water samples amount of		
	Soil*	Well Water*	Na^+/ppm*	K^+/ppm	Ca^{2+}/ppm
10. Kopay (not cultivated)	23.5	14.0	156	3.8	23
11. Uduvil (not cultivated)	26.5	15.0	—	—	—
12. Chankanai (not cultivated)	24.5	4.0	1702	7.8	38
13. Naranthanai (not cultivated)	38.3	14.2	3381	35.2	32
14. Chavakachcheri (Paddy cultivation)	1.2	1.5	53	6.0	6.6
15. Mirusuvil (not cultivated)	8.5	1.2	76	32.8	9.4
16. Tellipalai (not cultivated)	5.2	5.3	104	2.4	29
17. Erlalai (cultivated)	40.0	28.0	64.4	1.4	21
18. Kadduvan (not cultivated)	28.0	8.6	140	6.3	31.5
19. a) Karaveddy (not cultivated)	11.4	17.0	621	3.5	35.5
b) Karaveddy (cultivated)	31.6	38.0	759	4.3	34.8
20. Thampachetty	21.3	17.5	621	25.8	21

* Amount of Nitrate — Nitrogen in soil is expressed as μg of Nitrate - Nitrogen per g of soil where as that in well water as μg of Nitrate – Nitrogen per ml of water. The sodium values given are values corrected for interference by calcium.

Table 2. Jaffna Municipality Water Supply

	December 1976	December 1980	February 1982	May 1982
i) Thirunelvely water supply	15*	22	26.3	27.2
ii) Kondavil water supply	22*	30	33	34

* Report from water resources board — Jaffna.

4. Conclusion

The Nitrate-Nitrogen level in well water in the Jaffna Peninsula is well above the safe level of .10 ppm and is increasing year by year. The possible reason for this is the increase in the use of fertilizer.

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