OCCASIONAL PUBLICATION OF THE INSTITUTE OF ENERGY TECHNOLOGY

NITRATE CONTENT OF MALTA AND GOZO TAPWATERS

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October 1991

EXECUTIVE SUMMARY

The aim of the present investigation was to determine the quality of tapwater, with respect to nitrate content, as it actually reaches the consumer and how this quality varies for consumers living in different areas of the Maltese Islands. Nitrate in drinking water originates from contaminated groundwaters since reverse osmosis (RO) water is nitrate-free. Aquifers receive nitrates mainly from agricultural fertilizers but possibly also from sewage water and other sources. Nitrate is a health hazard and is known to cause infantile methaemoglobinaemia in newborns and is suspected to increase the incidence of stomach cancer in adults. The WHO guideline value for nitrate is 45 ppm.

Tapwater from various localities in Malta and Gozo were analyzed during the period July - October 1991. The results showed that nitrate concentrations varied dramatically from barely detectable in certain localities to very high values, >100 ppm, in certain areas in central Malta and in parts of Gozo. In view of the toxicity of nitrates, the present situation warrants a remedy without delay. A solution to the problem would involve a more rigorous mixing programme of the two water types, *i.e.* RO and ground supplies, prior to distribution to consumers. An alternative or parallel approach would involve the use of an RO plant for the purification of high nitrate groundwater. The energy demand of such a plant would be much lower than that of RO plants running on seawater. Such a solution could be especially useful for Gozo, which in the meantime, should have its nitrate values reduced by being provided with adequate blending facilities and with RO water from the Cirkewwa plant.

INTRODUCTION

The supply of safe drinking water is a major problem in both developed and developing countries. In the former, there is usually an adequate control of the bacteriological quality of the water although over the last thirty years, the contamination of supplies by inorganic and organic pollutants, with concomitant health problems, has been growing.

One frequent contributor towards inorganic pollutants in drinking water is the nitrate ion, NO_3^-. Newborn babies are especially sensitive to nitrates: ingestion of the pollutant causes infantile methaemoglobinaemia and, in extreme cases, even death (1, 2). In adults, nitrates are suspected of increasing the incidence of stomach cancer (3, 4).

Nitrate is not, typically, a constituent of rocks but it is usually derived from topsoil from where it leaches out and eventually seeps into the water table. Arable land is probably the main contributor to nitrate in aquifer water. Artificial fertilizers provide the major share of nitrates in soil. Animal manure also degrades with the release of nitrates but at a slow rate.

Domestic sewage water is another potential nitrate source. Broken or cracked pipes and breached cesspits could contribute to aquifer nitrate, although nitrate from such sources would be accompanied by other characteristic pollutants such as alkylbenzensulphonate detergents and pathogens. Other nitrate sources include leachates from refuse dumps and washout of urban and industrial atmospheres laden with nitrogen oxide (NO_x) gases.

Groundwater produced from galleries, boreholes and springs derives from the water tables of Malta and Gozo and its quality will reflect the type and intensity of human activity occurring over the land surface constituting the catchment areas of the aquifer.

It is known that the weighted average value of the nitrate concentration in Malta groundwater is about 70 ppm with a range from 20 to 200 ppm (5). Groundwater constitutes about 45 % of the total water budget, the rest being supplied by reverse osmosis (RO) plants. Flash distillers at the Marsa Power Station also contribute towards fresh water production, but not very significantly. Water from RO plants is practically nitrate-free.

The nitrate content of water reaching the consumer is expected to be locality-dependent. Its value is determined by two main factors: [1] the nitrate content of the particular groundwater source being tapped and [2] the mix ratio employed in producing the blend which is ultimately supplied to the consumer living in the given locality.

The aim of the present investigation was to determine the quality of tapwater with respect to nitrate content as it actually reaches the consumer and how this quality varies for consumers living in different areas of the Maltese Islands.

MATERIALS AND METHODS

Water samples were collected in clean plastic or glass containers which were repeatedly rinsed with the water being sampled before fill-up. The samples were kept under refrigeration until analysis which occurred within about one week of collection. The samples were collected over the period 12 July 1991 to 11 October 1991. The sampling programme involved five separate sampling episodes.

The technique used for nitrate determination was the Ultraviolet Spectrophotometric Screening Method recommended by the American Public Health Association for uncontaminated natural waters and potable water supplies (6). A Perkin Elmer Lambda Series uv/visible double beam spectrophotometer was employed. The nitrate calibration curve follows the Beer-Lambert Law up to about 11 ppm. Absorbance measurements at 220 nm and at 275 nm were made; any contribution to the absorbance at the lower wavelength by soluble organic matter was compensated for by the measurement at 275 nm. It was found that, in practice, this empirical correction was not normally required. Serial dilution of the water samples using deionized distilled water was performed on concentrated samples.

RESULTS AND DISCUSSION

The results of the nitrate analysis are shown in Table 1. The World Health Organization guideline value for nitrate is 45 ppm (7).

Tapwater nitrate concentrations can be grouped into four distinct domains which we have arbitrarily defined as in Table 2. The colour descriptors are for convenience only.

Each domain is associated with a particular, if diffuse, geographical zone.

Thus, the area stretching from Siggiewi through Rabat to Misrah Kola, Attard and Lija is a nitrate Red Zone, characterized by very high nitrate values, reaching a maximum of 135 ppm NO_3^- at Rabat, Malta. The areas in the Orange Zone, namely, Balzan, Zabbar/Marsascala, Mellieha/Xemxija and towns in Gozo have nitrate contents which are significantly above the WHO guideline value but are markedly lower than those in the Red Zone. Certain Gozo towns, however are decidedly Red Zone areas (see Table 2). The Green Zone refers to a third group of values which are within the WHO guideline; Zurrieq, Santa Lucia, Tarxien, Zejtun and Cospicua are Green Zone areas. A fourth domain, the Blue Zone, is characterized by very low to practically negligible nitrate concentrations. Blue Zone tapwaters are those in Valletta, Sliema, Guardamangia and Kappara.

An examination of the water distribution network for Malta (8) affords a rationale of these results. From the water works map and the values in Table 1 it can be inferred that certain areas in Malta are being supplied wholly or predominantly from groundwater sources which are frequently nitrate-rich. Such areas are those towns found in the high-nitrate Red Zones. On the other hand, the low-nitrate Blue Zones appear to be receiving direct supplies of RO water which is practically free of nitrate.

The greater the RO water contribution to a blended water mix, the lower is its resultant nitrate concentration. Thus, for example, it appears that while Zurrieq, a Green Zone area, receives a properly adjusted RO-gound water blend, Siggiewi, in the Red Zone, is either not receiving any water from the Lapsi RO or the blending ratio is far too rich in groundwater. The distribution map suggests the former.

Gozo has no RO plants although there is one flash distiller at Hondoq ir-Rummien which is in very intermittent use because of its high running costs. The results of this investigation suggest that the island relies almost completely on its groundwater supplies. The different nitrate values found in Gozitan towns presumably reflect the water quality of the production source which happens to be in use in the different localities. It is not known whether any blending of local groundwater occurs prior to distribution, although the nitrate values suggest that no such blending is being attempted. In any case, it is disturbing to note that most towns in Gozo receive water which exceeds the nitrate guideline value sometimes by a wide margin.

A long term solution to the nitrate problem in drinking water would address the rate of pollution of the aquifer from agriculture. In Malta, agricultural land has dwindled by a third from 1957 to 1986 (9). Efforts to maintain food production are bound to involve increased use of fertilizer which, given the rapidly decreasing number of farm animals, would have to be mainly of the artificial type. In this perspective, the need for a more rational use of nitrate fertilizers becomes critical. The farming community must be made to realise the exigency for a more rational use of such materials. Application of some form of fertilizer price disincentives might be considered although such a stratagem could easily simply result in increased produce prices at the market place. In any case there is an approximate three year time lag before the effects of any surface changes appear in borehole water (5).

In the short term, public health considerations would require that drinking water nitrate content be reduced, without delay, to values within the 45 ppm limit. Complete reliance on RO water would prove prohibitively expensive. With roughly half the present supply coming from RO sources, 25% of generated electrical energy is reportedly being taken up by the RO plants. We suggest that the country could not afford to commit half its energy production towards water generation, as required by the RO water-only scenario, especially when one also considers the present, hugely subsidized, domestic water rates. Groundwater is a valuable resource which can and should continue to be used sustainably with comparatively low energy input, between a sixth and a ninth for that of RO water.

However, the present distribution practice of supplying certain districts with pure RO water while providing others with unblended ground supplies is difficult to justify on public health grounds. It would seem likely that, for a more equitable distribution of "Green Zone water", a considerable part of the new Pembroke RO output would need to be blended with ground supplies presently reaching the Red Zone areas in central Malta. Such a strategy may or may not require the laying of new pipework and/or the construction of new blending rooms.

Considering the weighted average nitrate concentration of groundwater (70 ppm) and its share of the water budget (45%) together with the corresponding values for RO water (respectively 0 ppm and 55%) it is theoretically possible to obtain a water blend for the Maltese islands with a nitrate concentration of about 30 ppm. Admittedly, it may be logistically difficult to prepare and distribute globally this idealized blend; but at least every attempt should be made at blending groundwater supplies with RO produce in order to comply minimally with the WHO guideline if not to approach the idealized blend concentration of 30 ppm.

An alternative or parallel approach may involve the setting up of a new RO plant made to work on high-nitrate groundwater instead of seawater. The lower total salt content of such feed water would imply much reduced costs: working pump pressures may be only 1/50 of that in a seawater RO and the recovery fractions may be much higher. In addition, the process will be exploiting a natural resource which, at present, may either not be utilized (*i.e.* abandoned boreholes), or worse, may be utilized improperly (*i.e.* very high nitrate boreholes currently on stream). Indeed, such an RO plant intended to "polish" low quality groundwater could be the most viable strategy for Gozo, an island which is apparently endowed with an abundant, if nitrate rich, supply of natural water. Such a project would be favoured once the projected 132 kV transmission lines are installed. In the meantime, Gozitan nitrate levels could and should be immediately reduced by making available adequate blending facilities and sending RO water from Cirkewwa along the submarine pipeline, for blending with the local supply.

CONCLUSION

Nitrate concentrations in Maltese tapwater taken from different parts of the country show that while households in certain localities are receiving good to very-good quality water, others are receiving water with an unacceptably high nitrate content. As nitrate is a health hazard, the present situation should be remedied without delay. An obvious solution to the problem, which may not be without technical difficulties, would involve a more rigorous mixing programme of the two water types, *i.e.* RO and ground supplies, prior to distribution to consumers. An alternative or parallel approach would involve the use of an RO plant for the purification of high nitrate groundwater. The energy demand of such a plant would be much lower than that of RO plants running on seawater. Such a solution could be especially useful for Gozo, which in the meantime, should have its nitrate values reduced by being provided with adequate blending facilities and with RO water from the Cirkewwa plant.

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TABLE 1

NITRATE IN TAPWATER DURING SUMMER 1991

Locality	*Nitrate Concentration (ppm)*				
Sampling session[1]	1	2	3	4	5
Attard (centre)	75,	60	67		
Attard (St Catherine)		127			
Balzan	65		55		
Cospicua					38
St Lucia	27			22	
Valletta	2				
G'Mangia	0.5			nd[2]	
Sliema	0.4		nd		
Misrah Kola		72			
Zabbar	54	95			42
Zurrieq	20		24		
Tarxien	38			28	
Xemxija	39		65		
Rabat, Malta	110	106	135		
Msida		69			10
Siggiewi		100	99		
Tar-Mirakli (Lija)		121	118		
Kappara			4		5
Zejtun			33		39
Mellieha					65
Marsascala					64
St Paul's Bay					0.5
Rabat, Gozo			72		
Qala				88	
Mgarr ix-Xini				103	
Dwejra				55	
Dahlet Qorrot				46	
Sannat				60	

[1] The dates for the five sampling sessions were as follows: 1: 12/7/91, 2: 24/7/91; 3: 27/8/91; 4: 26/9/91; 5: 4/10/91.

[2] nd = not detected.

TABLE 2

TAPWATER NITRATE BY ZONE

Nitrate Range (ppm)	*Descriptor*	*Locality*
> 65	Red Zone	Attard, Rabat (M), Siggiewi, Lija, Rabat (G), Qala, *etc.*
46 - 65	Orange Zone	Balzan, Zabbar, Xemxija, Marsascala, Sannat, *etc.*
11 - 45	Green Zone	Cospicua, Zurrieq, Zejtun, Tarxien, *etc.*
0 - 10	Blue Zone	Sliema, Valletta, Guardamangia, *etc.*