NITRATES IN BORE WATER: CAUSE

In June 1991 a member of a large extended family living on a small hobby farm near Oberon, NSW, contacted the Orana and Far West Public Health Unit for advice about the family's bore water supply. Tests conducted on water drawn from a bore on the property showed that it contained 38mg/L nitrate (as nitrogen) and was unfit to drink. On the day these results became available the family switched to drinking rainwater exclusively. Within a few days of doing this, health problems experienced by the whole family disappeared.

All 10 family members, ranging in age from 6 to 65, had a six-month history of symptoms of breathlessness, fatigue, chest pain and muscle cramps (Figure 1). The three adult males were employed and spent most of their weekdays away from the farm. Two of the men had relatively minor symptoms. The third male was the most severely affected family member. He also worked in town but he drank large quantities of tea and coffee while at home (20-30 cups a day). He had severe and persistent muscle cramps for more than six months. A subsequent muscle biospy was normal. All female family members spent most of their time on the farm and the children were educated at home. The family had consulted its local general practitioner who corroborated this history. Sheep and peacocks on the property also drank bore water and have been unwell.

The family has lived on this farm for three years. Its members eat a mixed diet of meat and vegetables. Spinach and lettuce are grown in the garden and watered with bore

Blue-green algae at Lake Cargelligo

► *Continued from page 110*

TABLE 2

SYMPTOMS AMONG 95 LAKE CARGELLIGO SCHOOL CHILDREN

Nausea	74 (79%)
Abdominal cramp	57 (60%)
Headache	54 (57%)
Vomiting	37 (39%)
Fever	12 (13%)

contaminated water. Ninety-five children (17 per cent) were ill during this period. The frequency of reported symptoms is shown in Table 2.

The two medical practitioners at Lake Cargelligo had seen about 20 adults and children in the previous month with symptoms believed to be those of viral gastroenteritis. Two instances of conjunctivitis and one of a rash had been attributed to swimming in the lake. Liver function tests were performed in eight of these people and all results were normal. In the four patients in whom viral blood tests were performed, the results were inconclusive.

On December 24 the Lake Cargelligo water supply was proclaimed safe for human consumption. The bloom of *Anabaena* disappeared but of concern was a subsequent bloom of another potentially toxic algae, *Microcystis*. The NSW Department of Water Resources predicted that blue-green algal blooms are likely to recur in Lake Cargelligo this summer. Weekly monitoring and toxicity assays are to be instituted.

EDITORIAL NOTE

Ensuring the provision of uncontaminated drinking water has been a canon of public health practice since the time of John Snow. Across much of the Australian continent potable water supplies are threatened by the eutrophication of our inland lakes and rivers. Eutrophication is an alteration in the balance of nutrients such as phosphates in these waterways, favouring the proliferation of blue-green algae (cyanobacteria) and other unwanted micro-organisms. The major causes of eutrophication are phosphate- and nitrate-based fertilisers and sewage from human population centres and livestock. Australian Bureau of Statistics data[4] indicate that total tonnage of superphosphate fertilisers used in the Central West of NSW increased by 21.8 per cent in the two years from 1986 to 1988. Even more significantly, the use of superphosphate fertilisers in the Central Tablelands statistical subdivision, where the Lachlan River which flows into Lake Cargelligo rises, increased by 94.3 per cent in the same period.

The most likely explanation of the apparent infrequency of human illness caused by algal toxins is that the unpleasant taste and odour of the contaminated water is an effective deterrent to ingestion. The potential toxicity of long-term, low-dose exposure to these toxins or their effect on sensitive subgroups in the population is unknown.

The Palm Island incident is an illustration of why copper sulphate has fallen into disrepute as an effective treatment for algal blooms. Furthermore, the elimination of one species, as was seen in Lake Cargelligo, can rapidly be followed by an overgrowth of a different species. Rainfall or increased flows can flush out a bloom. Individual town water supplies can be secured by the installation of charcoal filtration systems. In the long term, prevention of eutrophication of inland waterways will depend on changes in methods of waste water treatment, agricultural and land management practices.

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water. No artificial fertilisers are used on the land. Neighbouring land is used to graze cattle and some artificial fertilisers are used on this property. The bore was sunk to only five metres and was on the side of gently sloping land below another farm. It was the only source of drinking water for this family and the animals on the farm.

Water from the bore was tested not because of the presence of symptoms, but for water hardness before the family installed a new hot water system. The family was advised on June 26, 1991 that the water was unfit to drink because of high levels of nitrate. The level of 38mg/L of nitrate (as nitrogen) exceeds the maximum level recommended by the National Health and Medical Research Council (NH&MRC) in Australia for nitrate in drinking water of 10mg/L[1]. The water also contained high levels of calcium salts. No faecal coliforms or other organisms were detected in the water.

Shallow bores such as the one on this property can easily become contaminated during periods of flooding by run-off containing chemical fertilisers uphill from the bore. A reported flood in the area in August 1990 could have caused a rapid increase in nitrate levels of the bore water, but the source of the nitrate contamination in this bore is unknown.

The symptoms experienced by family members may have been due to chronic methaemoglobinaemia (MHA) caused by high levels of nitrate in their drinking water. However, blood taken from one family member five weeks after the family switched to drinking rainwater contained no methaemoglobin (MetHb). Nitrates may also cause some of these symptoms independently of their ability to oxidise haemoglobin (Hb). Although other causes for these symptoms have not been excluded, the high nitrate levels, more severe symptoms in those with the greatest exposure and the rapid disappearance of symptoms in all family members after they stopped drinking bore water support this conclusion.

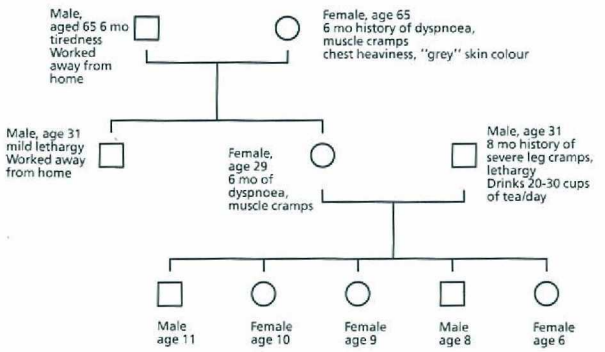
Reports of MHA in adults are rare. It causes symptoms of lethargy and breathlessness when it comprises 30-45 per cent of total Hb[2]. In adults, the dose of nitrates needed to produce these levels of MHA is unknown. The estimated total daily intake of nitrates (as nitrogen) in an average western diet is 75mg/person/day[3]. Water usually contributes only 3-5 per cent of this total. Assuming that the adults in this family consumed two litres of water daily, the average daily consumption of nitrates would have been about 150mg/day.

EDITORIAL NOTE

Nitrates are not essential for normal human function and are present in most diets and in drinking water. Some foods such as spinach, rhubarb, carrots, lettuce and preserved meats contain high levels of nitrates[4]. Surface water rarely contains high levels of nitrates as they are metabolised by plants. Ground water, however, may contain high levels. Nitrates can enter underground aquifers through seepage from surface water contaminated with human and animal waste (eg from feedlots, farmyards and septic tank systems); from the run-off of nitrogenous fertilisers applied to the land; from rubbish dumps; and from the natural leaching of nitrates from the soil. Nitrate levels in ground water may rise rapidly in shallow bores when a period of drought is followed by heavy rain. Identification of the source of nitrates in water is difficult, and once dissolved in ground water, nitrates are not easily removed.

FIGURE 4

HISTORY OF ILLNESS IN AN EXTENDED FAMILY DRINKING NITRATE CONTAMINATED UNDERGROUND WATER



All children had a 6 month history of irritability, lethargy and muscle cramps

Levels of nitrates higher than the NH&MRC recommended levels have been reported in many places throughout the State in bores tested by the Department of Water Resources (DWR)[5]. Of 14,000 samples tested over the past 20 to 30 years, only 287 (or 2 per cent) were above 10mg/L, with the highest level recorded of 56mg/L. The problem of nitrate contamination, although widespread, is not common. The number of domestic bores licensed by the DWR is 18,379. There are 523 bores supplying town water. The known 17,856 bores used for private, domestic, stock and general purposes probably underestimates the real number by a factor of three or four[6]. The estimated number of people in rural NSW who rely on either rainwater tanks or water from private bores is 350,000. Bores providing town supplies are tested regularly by local councils and the Health Department and water is used only if nitrate levels are below 10mg/L. Many private bores are not tested regularly.

Methaemoglobinaemia is a rare condition which may be inherited or acquired through exposure to nitrates and nitrites, aniline dyes, sulfonamides and other chemicals. Nitrites are a potent cause of MHA. Nitrates are converted to nitrites by micro-organisms in soil, water, sewage and the human stomach.

In the acquired condition, chemical changes occur within red blood cells which reduce the ability of these cells to carry oxygen to the body's organs. Normal Hb is oxidised to MetHb, which cannot combine reversibly with oxygen. MHA occurs when the percentage of this oxidised form of Hb exceeds 2 per cent of the total Hb.

At levels of 10 per cent MetHb, shortness of breath and cyanosis can occur. At a methaemoglobin level of about 35 per cent, the affected individual experiences headache, weakness and breathlessness, although symptoms may vary according to the other effects of the particular agent involved. Levels higher than 80 per cent are probably lethal.

MetHb is spontaneously reduced to normal Hb in the body, with about half reverting spontaneously within about 24 hours. Babies and infants less than three months old are more susceptible to MHA for several reasons. First, the fluid intake of infants per unit body weight is about three times that of an adult and second, foetal Hb — which is the predominant form at birth — is more suspectible to MetHb formation than adult Hb. Infants are more vulnerable to

Continued on page 118 ►

above, and the National Health and Medical Research Council gets great value for its investment. Leadership and personalities are also important.

Smith R. Top of the pile: the institutes. *Brit Med J* 1991, 302:1006-1010.

SCREENING FOR CONGENITAL HIP DYSPLASIA

Screening for congenital hip dysplasia remains controversial because the diagnosis is not always easy and treatment carries some risks. The risks of treatment (which involves splinting of an unstable hip) are that the blood supply to the bones of the hip joint may be interrupted, causing serious problems.

In Australia screening is done soon after birth by clinical examinations conducted by medical staff. These are often followed up through the Early Childhood Health Services by nursing staff who routinely check hips at about four weeks and six months of age. In other countries, such as Germany, all infants are screened ultrasonically at birth and elsewhere a more selective screening policy has been pursued.

Editorial: Screening for congenital hip dysplasia. Lancet 1991, 337:947-948.

ULTRAVIOLET A RADIATION — STAYING WITHIN THE PALE

In simplistic terms, sunlight is composed of both ultraviolet A and ultraviolet B radiation. Ultraviolet A is particularly notable for its ability to tan before burning. Ultraviolet B radiation is the villain causing burning and is probably more associated with cancers of the skin. But both UVA and UVB cause the blotchy brown wrinkling of skin that accompanies ageing and adversely affects immunological resistance. Many sunscreens protect against the burn effects of UVB and thus allow constant sunbathing leading to tanning. But it has now been realised that a tan without burning still leads to long-term damage.

An obvious solution is to seek clothing and trees for shelter rather than sunscreen ointments. However new sunscreen ointments contain chemicals which reflect both ultraviolet A and B.

Hawk JLM. Ultraviolet A radiation: staying within the pale. *Brit Med J* 1991, 302:1036-1037.

PREVENT FALLS AND OSTEOPOROSIS

Hip fracture is the most serious consequence of osteoporosis, and more than 90 per cent of such fractures occur in people over 70 years old. A dramatic age-related increase in rates of hip fracture is widely believed to result primarily from post-menopausal and age-related osteoporosis. But preventive measures recommended to slow perimenopausal bone loss, including estrogen replacement therapy, may be less beneficial for elderly women whose bone mass may be inadequate to prevent fractures.

An American study has shown it is important to prevent falls as well as to prevent osteoporosis. Risk factors for falls include lower limb dysfunction, neurological conditions, sedative use and visual impairment.

Grisso JA, Kelsey JL, Strom BL, Chiu GY et al. Risk factors for falls as a cause of fracture in women. *New Eng J Med* 1991, 324:1326-1331.

Nitrates in bore water

► *Continued from page 114*

nitrate-contaminated water because of higher pH levels in their stomachs resulting in greater concentrations of nitrate-reducing bacteria.

MHA from drinking water with high nitrate levels was first reported in 1945. Cases of fatal and non-fatal MHA in infants due to bore water nitrates have been reported in the US, Canada, Belgium, England and Mexico[7,8]. Most cases were associated with water from private bores where nitrate levels were above 20mg/L and which were also contaminated with microorganisms. Microbial infections may exacerbate the effects of MHA.

PREVENTION OF BORE WATER MHA

Infant milk formula: Infants, particularly if bottle-fed, are at greatest risk of MHA and therefore steps taken to protect them should also protect other water users. Bore water should not be used to make up infant milk formula when nitrate levels exceed 10mg/L or nitrite levels exceed 0.1mg/L[1].

In towns supplied with bore water, where nitrate levels are just below 10mg/L, parents should be advised that excessive evaporation of water during boiling can concentrate nitrates and nitrites in the water. Lids or enclosed containers should be used to boil water.

Bore construction: The contamination of bore water by run-off and seepage from septic tanks is less likely in deeper bores. Bores should be sited uphill from obvious pollution sources, such as septic tanks, and properly sealed at the surface to avoid direct run-off contamination around the exposed bore casing. The DWR can advise on the best methods to locate and construct bores.

Regular testing of private bores used for drinking: Bore water should be tested twice yearly for its suitability for drinking purposes. Testing should also be conducted during periods of prolonged drought and after heavy rains following drought, especially in catchments with intensive fertiliser use and developments with numerous septic tanks and nearby rubbish tips.

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