Uranium levels in New Zealand soils and fertilisers

Uranium analytical method

The current method used to measure uranium level in soils and fertiliser is referred to as ICP-MS (Inductively Coupled Plasma – Mass Spectrometry). The analytical method employed to measure uranium levels in fertiliser and soils is the same. There is no separate method employed to assess safe level or abnormal level of uranium in fertilisers or soils. The detection limit of ICP-MS method is 0.1 ppm with the coefficient of variation of 10% of 1 ppm which is 0.1 ppm. For example a sample analysed for uranium containing 1 ppm of uranium will be reported as 1.0 ± 0.1 ppm.

The ICP-MS method can detect uranium in soil and fertiliser with a detection limit of 0.1 ppm and accuracy of 0.1 ppm for 1 ppm uranium.

Natural abundance of uranium

Like all natural elements, uranium is present in all ecosystems. The average global natural abundance of uranium in the earth's crust is 2.3 ppm and in soils is 1.8 ppm. In New Zealand it ranges from 1.1 to 2.3 in soils according to the information obtained from Rothbaum *et al.,* 1979, Furness, 2000. The mean concentration of uranium in drinking water is 1.8 pCi/L (2.7 µg uranium/L or 2.7 ppb). Uranium is radioactive with a half-life of 4.5×10^9 years for uranium-238. Uranium-238 represents 99% of the naturally available uranium.

The natural abundance of uranium in New Zealand soils ranges from 1.1 to 2.3 ppm.

Uranium in phosphorus fertilisers

Levels of uranium in superphosphate are due to the raw material (i.e. rock phosphates) containing high levels of uranium. Depending on the source of rock phosphate the level ranges from 15 to 148 ppm. Rock phosphate is used in organic farming as a source of phosphorus. Superphosphate is manufactured by acidulating rock phosphate with sulphuric acid. The level of uranium in superphosphate is affected by the level of uranium in rock phosphate which in turn is affected by the country of origin. According to Rothbaum *et al*. (1979) the superphosphate used from 1954 to 1975 was made from rock phosphate from Nauru and Christmas Island with an average uranium level of 42 ppm (range 25 to 50).

According to a report from the Fertiliser Manufacturer's Research Association (Furness, 2000), New Zealand sourced its rock phosphate from North Carolina (65 to 69 ppm U) and Nauru (54 to 64 ppm U) in the 1970's. Furness (2000) indicates that currently rock phosphate is imported from China (12 to 18 ppm U) and the Middle East (45 to 80 ppm U). Currently Ravensdown Fertiliser Co-op source its raw material from China and Nauru whilst the common sources for BOP Fertiliser Ltd are South America, Morocco and Nauru, resulting in superphosphate with the uranium levels of 34 and 43 ppm respectively as sampled.

The fertiliser analysis report from ECO SOILS Research, Tauranga, gives a range of 30 to 45 ppm of U for superphosphate manufactured in NZ. This range is realistic given the sources of rock phosphate used in NZ.

Long-term uranium accumulation in soils

Superphosphate contains 9% of phosphorus (P). In New Zealand, typical annual P application rate for arable crops is 35 kg P/ha (390 kg superphosphate) and for dairying (at maintenance level) 5.5 kg P/ha (60 kg superphosphate). Assuming a level of 45 ppm (worst case scenario) of uranium the amount of uranium applied at 390 kg/ha superphosphate application rate will be 17.6 g/ha. Assuming a background level of 2 ppm of uranium for NZ soils, the increase in uranium level as a result of phosphorus fertiliser application will be 0.01 ppm (assumptions: soil bulk density = 1 g/cm^3; soil depth within which uranium is adsorbed = 15 cm). Such an increase is not detectable using the modern technology such as ICP-MS. If the fertiliser is applied for half a century at 390 kg/ha/year rate, the accumulation of uranium will be 0.6 ppm. Such an estimate assumes no other loss pathways (crop/product removal, surface run-off, leaching losses) for uranium.

For dairy pasture soils the accumulation rate of uranium will be much lower. At the application rate of 60 kg/ha/year superphosphate with a uranium level of 45 ppm the amount of uranium applied to soil will be 2.7 g/ha/year. At this rate of accumulation it will take 325 years to reach same uranium levels in arable soils after 50 years of phosphorus application.

There are few reported investigations performed in New Zealand on long term accumulation of uranium in agricultural soils. A study performed by Rothbaum *et al*. (1979) examining uranium accumulation in UK and NZ soils showed that the natural level of uranium in a soil from Papatoetoe was 2.3 ppm (averaged from 3 depths between 0-15 cm). After 20 years of superphosphate application at the rate of 37 kg P/ha/year (410 kg superphosphate/ha/year) the level was 2.6 ppm (averaged from 3 depths between 0-15 cm).

A report by Furness (2000) showed that an arable soil at the Winchmore Research Station with a uranium level of 1.0 ppm in 1958 reached 1.5 ppm in 1998 following an annual superphosphate application rate of 376 kg/ha/year.

From the above studies and other related information on uranium, it is clear that to elevate natural soil uranium level two fold from 2.3 to 4.6 ppm would require approximately two centuries of superphosphate use. Depending on the rate of application and the source of

reactive phosphate rocks (RPR) organic farming system may accumulate relatively more uranium. This is because in general RPRs contain more uranium than superphosphate.

The current rate of uranium accumulation in agricultural soils is not significant compared to the natural uranium levels in New Zealand.

Food safety

Currently there is no guideline available on the safe level of uranium in soils or fertilisers. The safe level for uranium can vary depending on the issue. Safe levels of uranium should be linked to radiation exposure to excessive uranium and chemical toxicity arising from uranium being in the food chain.

It appears that although uranium accumulates slowly in soils following superphosphate application, this did not result in increased uranium uptake by crops. From the research paper by Rothbaum *et al*. (1979) wheat grown on long-term phosphorus applied soils contained uranium below detection limit. Nevertheless, these workers estimated that crops could have removed a total of 10 g U/ha in 88 years of crop harvest. According to an American work cited by Furness (2000) there was no difference in uranium levels between crops grown in soils received long-term superphosphate application and crops from unfertilised plots. Therefore from food safety and chemical toxicity viewpoint the levels of uranium in phosphorus fertilisers should not be a major concern. The New Zealand Dairy Group, based on the information it has available, does not consider there is a risk to our food supply.

Uranium accumulation in soil due to superphosphate application should not threaten food safety.

Radiation issue

Cosmic radiation and natural radioactive materials present in the environment cause radiation in nature. People in NZ are exposed to a radiation dose of 2 milli-Sieverts/year. According to the International Commission on Radiological Protection an exposure of up to 10 mS/year would not warrant any intervention to reduce exposure. A one-off work performed for BOP Fertiliser Ltd showed that the levels of radiation were minimal from rock phosphate. The levels detected were 10-100 times lower than that produced from a household smoke alarm. Moreover, information obtained from the National Radiation Laboratory suggests that the radiation effects from the fertilisers or soils with accumulated uranium are not significant.

The levels of uranium in superphosphate and soils are not considered as harmful from radiation viewpoint.

Conclusion

In short, uranium is present in nature. Application of rock phosphate derived fertilisers will result in uranium accumulation in agricultural soils. The long-term accumulation rate is not significant enough to be a health hazard.

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