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Seasonal Variation of Arsenic Concentration in Well Water in Lane County, Oregon

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The United States Public Health Service has set a maximum limit for arsenic in public water supplies of 0.05 p.p.m. (mg/l), and advises that continuous consumption of water exceeding this level is potentially hazardous (U.S.P.H.S. Drinking Water Standards 1962). However, well and spring water exceeding this limit occurs in the U.S.S.R., Taiwan, Romania, New Zealand (Fleischer 1963; Tseng et al. 1968), and in areas of California, Nevada, Alaska and Oregon (Fleischer 1963; Whanger et al. 1977; Harrington et al. 1978). One such area of Oregon, in Lane and Douglas Counties, overlies the Fisher formation, which consists predominantly of tuffaceous siltstone and volcaniclastic sediments (Vokes et al. 1951). Apparently groundwater leaches arsenic from this material (Whanger et al. 1977), and in this area, arsenic levels in well water range up to 2 p.p.m. (Morton et al. 1976; Whanger et al. 1977). Although concerned area residents have been having their well water analyzed for arsenic by private and county laboratories, these analyses have usually been done once per well. The results of these analyses have often guided water usage. While the analytical techniques have been reliable, the use of single analyses could lead to incorrect conclusions as to water quality if the arsenic content fluctuates seasonally. Such incorrect interpretations could have significant medical and agricultural implications. We monitored the arsenic concentration in 14 Lane County wells over a 13 month period spanning 1975 and 1976. To the best of our knowledge, no studies of this type have been reported. This paper presents the results and recommendations from our study.

MATERIALS AND METHODS

For this study, 14 wells in Lane County were chosen for

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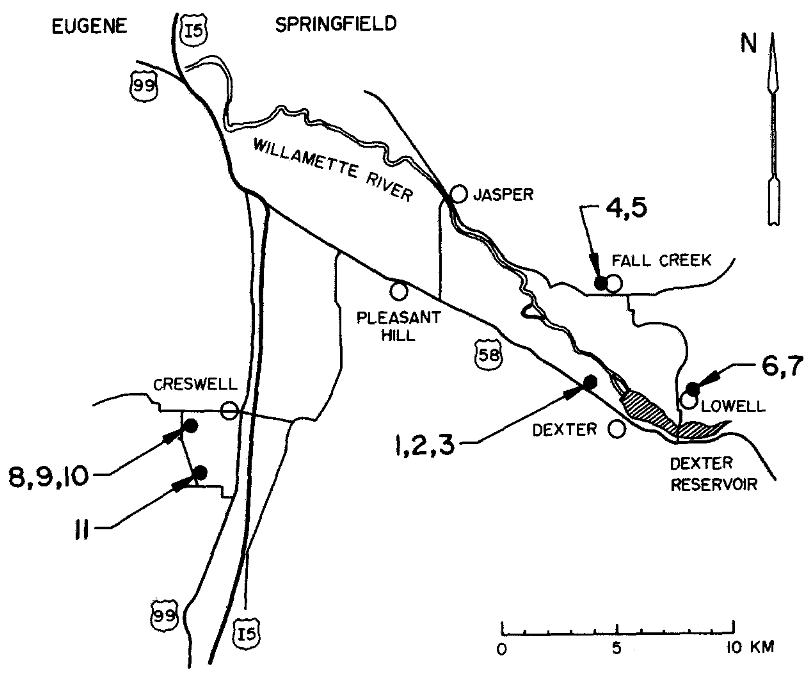

Fig. 1. Study area of Lane County, Oregon, showing well locations.

analysis. The geographical locations of 11 of those wells are shown on the map (fig 1). The three wells not shown (one from Lowell and two from Creswell) exhibited concentrations of arsenic and seasonal fluctuations of arsenic concentrations almost identical with those of well number 7 on the map. The municipal well system of the city of Lowell (semi-rural, pop. ca 600) was chosen because of excessive arsenic concentrations found in October, 1974 which prompted the Governor to declare the city a disaster area. In addition, two wells were volunteered by city residents. The other eleven wells were in rural areas used primarily for pasturage and were chosen because previous analyses had shown high arsenic concentrations in most. All of the wells were modern cased types of comparable depth (20-50 m) and none were near agricultural operations using arsenicals. The samples were collected on a weekly or biweekly basis and pH was measured at time of collection at the well-site. Arsenic analyses were done in batches usually within 48 hr of collection. Arsenic concentrations were determined by atomic absorption spectroscopy using a method based on that of Schmidt and Royer (1973). Arsine gas, generated by injecting sodium borohydride in alkaline solution into acidified aliquots of sample, was passed directly to a Varian-Techtron AA-5 spectrophotometer on a stream of hydrogen. Analysis of the calibration standards and blanks by a regression algorithm showed the determinations to be accurate to ± 10 to 15% (95% CL) for samples containing more than 0.020 p.p.m., and to ± 0.003 p.p.m. for those with less than 0.020 p.p.m. arsenic.

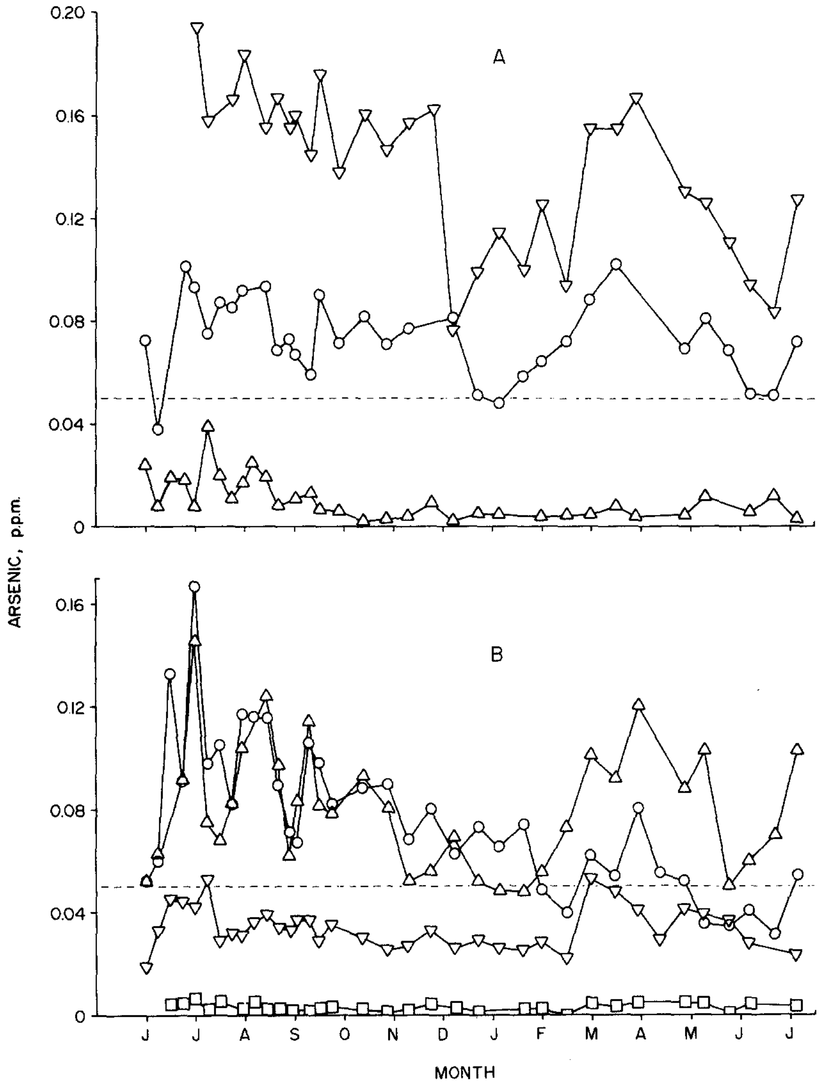

Fig. 2. (A) Arsenic levels between June, 1975 and July, 1976 in wells 1 (▽), 2 (O), and 3 (Δ). (B) Levels in wells 4 (O), 5 (Δ), 6 (▽), and 7 (□). Dashed line represents U.S.P.H.S. recommended limit of 0.05 p.p.m.

RESULTS AND DISCUSSION

Arsenic concentrations in water from the 14 wells followed several seasonal patterns. Figs 2A,B and 3A,B,C show the results for eleven of these wells. The results for the three wells not shown (one from Lowell, adjacent to well 6, and two from Creswell, adjacent to wells 8, 9, and 10) are substantially the same as for well 7 (fig 2B). The arsenic concentration in these four wells never exceeded 0.01 p.p.m. during the study period. Two wells, 2 (fig 2A) and 6 (fig 2B), had relatively constant concentrations, varying about ± 50% from mean value, while wells 1, 3 (fig 2A), 4,

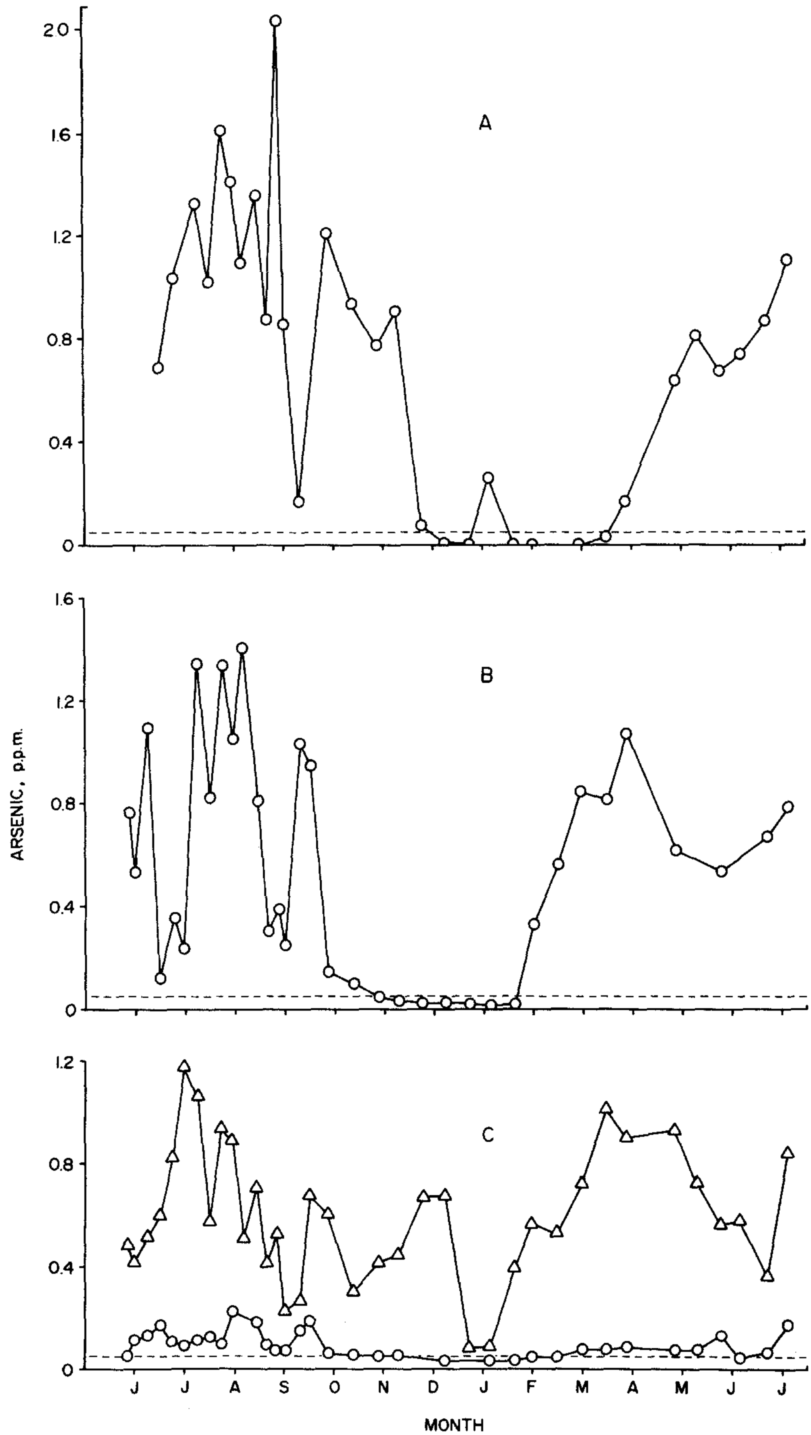

Fig. 3. (A) Arsenic level in well 8, (B) well 9, (C) well 10 (Δ) and 11 (O). Dashed line represents U.S.P.H.S. recommended limit of 0.05 p.p.m.

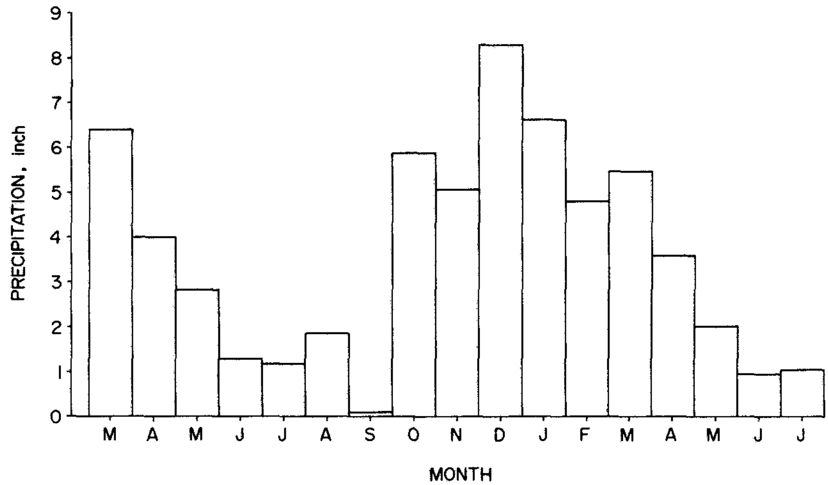

Fig. 4. Precipitation data was obtained at Dexter Reservoir from March, 1975 to July, 1976.

5 (fig 2B), and 11 (fig 3C) appear to show lower arsenic content in winter than in summer. In contrast, the arsenic content in wells 8, 9, and 10 varied dramatically (figs 3A,B,C). The arsenic content in well 8 reached 2 p.p.m. in late summer and was not detectable (less than 0.003 p.p.m.) during much of the winter. To assess whether this drop in arsenic content was due to surface rainwater seeping into the well and diluting its contents, well water collected in mid-December was tested for coliform bacteria. Significant titers of coliform bacteria are associated with surface water (Geldreich et al. 1968; Feachem et al. 1983). The results of these tests were negative, suggesting that the observed change in winter was not due to direct dilution of the well water by surface water.

There was no apparent correlation between arsenic concentrations and pH. Rainfall (fig 4), however, appears to be the major factor influencing the arsenic content in these wells, yet some of these wells also show large excursions and a spring peak that have no obvious relation to rainfall. The reason for this is not apparent. Rainfall could influence the groundwater arsenic content directly by recharging the aquifer, or indirectly through the water usage rate--if high pumping rates depress the water table in the vicinity of the well, deeper groundwater could enter the aquifer. The behavior of wells 8, 9, and 10 shows the complexity of the situation. These wells are within 100 m of one another, and are of similar depth (ca 50 m), but wells 8 and 9 are used for garden and pasture irrigation, while well 10 is for domestic use only. Two wells containing low arsenic concentrations year round are located between wells 9 and 10. These wells, however, were relatively shallow (ca 20 m). Well depth could therefore also be a contributing factor influencing well water arsenic content in the area of our study.

This study has shown that in some cases the concentration of arsenic in well water may vary seasonally, and may show large excursions at any time of the year. We were not able to determine any consistent geochemical or environmental factors to account for these variations. Therefore, accurate water quality assessment requires repeated sampling over an extended period. If this is not possible, optimal season for sampling should be determined locally. In Lane County, arsenic analyses of summer water samples are likely to be more valuable than winter samples in assessing water quality.

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