WISCONSIN MIGRANT WORKER CAMP DRINKING WATER QUALITY STUDY

USEPA Region V
Safe Drinking Water Branch

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Justification

President Clinton issued Executive Order 12898 on February 11, 1994 to establish environmental justice as a national priority. The order focuses attention on the environmental and human health conditions of minority and low-income populations. Soon after, USEPA Region V organized an Environmental Justice Workgroup to develop environmental justice policies throughout the region.

Through this regional effort, management and staff members of the Safe Drinking Water Branch focused on areas of the Public Water System Supervision (PWSS) Program where minority and low-income populations may be susceptible to greater risk from contaminated drinking water. One such population identified was migrant farm laborers.

Migrant laborers live and work in agricultural areas where pesticides and fertilizers are applied. However, the majority of the camps where they live and work are not regulated under the PWSS Program because the workers do not occupy the camps long enough, or in great enough numbers, to qualify for regulatory protection. The camps that are regulated under the PWSS Program are classified as transient non-community systems, only monitoring annually for nitrate and total coliform bacteria in some states. Since no pesticide monitoring is required at migrant worker camps (MWCs), and since it is probable that migrant laborers are exposed to more agrichemical contaminants than an average U.S. citizen, USEPA Region V's Safe Drinking Water Branch made the decision to look for pesticides in MWC drinking water.

Following the cryptosporidiosis outbreak in Milwaukee in 1993, the EPA's PWSS program placed its highest priority on targeting microbial agents in drinking water. EPA developed rulemaking processes to better study and regulate microbial contamination in drinking water. EPA is currently studying the prevalence of microorganisms and viruses in groundwater to determine the circumstances under which disinfection should be required for public water systems that use a groundwater source. Working together with the Wisconsin Department of Natural Resources (WDNR), and the Wisconsin State Laboratory of Hygiene (WSLH), the EPA included microbial and viral monitoring as a component of studying drinking water quality at MWCs. This was done as part of a broader, statewide study by the WDNR and the WSLH of viral and microbial prevalence in public water systems using a groundwater source.

Furthermore, in August 1996, the Safe Drinking Water Act (SDWA) was reauthorized by Congress. Provisions within the SDWA direct EPA to identify sensitive subpopulations; study the effects of potential endocrine disrupting contaminants; and use "sound science" in making regulatory decisions. For all these reasons, USEPA Region V chose to study drinking water quality at MWCs in Wisconsin.

Project Description

From May through October 1997, drinking water program staff from the WDNR and USEPA Region V collected drinking water samples each month from the 21 MWCs that are public water systems in Wisconsin. The drinking water samples were delivered to the WSLH, and analyzed for total coliform bacteria and *Escherichia coli.* Drinking water samples from MWCs were collected and analyzed from July through October for male-specific coliphages. Coliphages are bacterial viruses which have been proposed as potential indicators to monitor drinking water for the presence of pathogenic viruses.

One drinking water sample was collected monthly from each camp and analyzed for total coliforms. Each sample destined for total coliform analysis was collected in a sealed, sterile, plastic 100 ml bottle. Simultaneously at each camp, a 1000 ml drinking water sample was collected each month in a sterile, polypropylene sampling bottle and analyzed for coliphages.

Drinking water samples were analyzed for total coliforms and *E. coli* by the Colilert™ Method, and coliform contamination levels were quantified using the Quanti-Tray MPN Enumeration Test. When detections of coliforms occurred, bacterial species were identified using the API 20 E System. Coliphages were detected and enumerated according to a modified filter elution method followed by double agar layer (DAL) assay.

During June and September, besides the bacterial and viral monitoring, drinking water samples were collected and analyzed at the WSLH for the following contaminants:

2,4-D	carbofuran	endothall	metribuzin
alachlor	copper	glyphosate	nitrate
aldicarb	cyanazine	methomyl	simazine
atrazine	diquat	metolachlor	trifluralin

The contaminants 2,4-D, alachlor, aldicarb, atrazine, cyanazine, methomyl, metolachlor, metribuzin, and simazine were analyzed using enzyme linked immunosorbent assay methods, otherwise known as immunoassays. A 40 ml plastic centrifuge tube was used to collect the immunoassay samples.

Follow-up sampling was conducted at MWCs whose drinking water had immunoassay detections significantly higher than the method detection limit. Two 1 liter amber glass bottles were used to collect the drinking water sample from each camp. These analyses were performed using SDWA Method 507, "Determination of Nitrogen- and Phosphorous- Containing Pesticides in Ground Water by Gas Chromatography with a Nitrogen-Phosphorous Detector."

Diquat was analyzed in the drinking water samples by high performance liquid chromatography with ultraviolet detection, SDWA Method 549. Two 1 liter brown plastic bottles were used to collect the samples analyzed for diquat. Glyphosate was analyzed by direct aqueous injection high

performance liquid chromatography with Post-Column Derivatization, SDWA Method 547. Two 40 ml clear glass bottles were used to collect the glyphosate samples.

Endothall was analyzed using SDWA Method 548.1, by ion exchange extraction acidic methanol methylation and gas chromatography/mass spectrometry. Trifluralin was analyzed by gas chromatography with an electron detector, SDWA Method 508. Both the trifluralin and the endothall samples were collected in two 1 liter amber glass bottles.

Nitrate was analyzed as nitrate and nitrite nitrogen, using automated segmented flow analysis, EPA Method 353.2. Nitrate samples were collected in a 100 ml plastic bottle. Copper samples were collected in 250 ml plastic bottles. Copper was analyzed using inductively coupled plasma emission analysis, EPA Method 200.7.

Copper was selected for analysis in the study because copper compounds can be used in land applications as a fungicide. Copper's inclusion in this study is not intended to demonstrate its first-draw concentration potential from a MWCs distribution system water, but rather to determine if there is an environmentally significant contribution from the groundwater.

The 21 MWCs whose drinking water was studied are located in three geographic locations across Wisconsin. Sixteen of the camps are located in the east-central portion of the State, just west of Adams County within the Lake Michigan watershed. Four of the camps are located in the eastern portion of south-central Wisconsin. One camp is located in western Wisconsin, about 15 miles southeast of Eau Claire. Please see the map provided in Appendix 1.

A search of WDNR Well Construction and Inspection Reports was conducted to reveal environmental and construction factors that may limit or increase each MWCs susceptibility to contamination. The information that was available through these reports for each MWC is summarized in Table 1. Well construction records were found for 14 of the 21 MWCs. Most of the wells terminated in a sand or sandstone formation. The mean casing depth was 109 feet for the 14 wells with well construction records, with a maximum casing depth of 282 feet and a minimum casing depth of 40 feet. The mean total well depth was 155 feet for the 14 wells with well construction records, with a maximum well depth of 414 feet and a minimum well depth of 44 feet.

Results

Synthetic Pesticide Analysis

Six of the 13 synthetic pesticides tested for were identified in at least one MWC drinking water sample. The synthetic pesticides identified were alachlor, atrazine, cyanazine, metolachlor, metribuzin and simazine.

The contaminants 2,4-D, aldicarb, diquat, endothall, glyphosate, methomyl and trifluralin were not detected in any drinking water samples. Although historical data from public water systems in Wisconsin suggests a minimal likelihood of finding diquat, endothall, glyphosate, and trifluralin in

the drinking water, the non-detections identified for these contaminants in this study must be qualified. Fortified blank recovery for endothall analyses in June and September did not meet quality control limits, and the method holding times were exceeded for diquat, glyphosate and trifluralin in September. Therefore, there is a potential for false negatives from the endothall analytical results for June and September, and the diquat, glyphosate and trifluralin results for September. System-by-system results along with a statistical summary table of detections are located in Appendix 2.

Fifty-two percent (11/21) of the MWCs provided at least one drinking water sample that contained a detectable quantity of a synthetic pesticide. Atrazine and alachlor were detected in the drinking water at 48% (10/21) of the MWCs. Simazine was detected in the drinking water at 24% (5/21) of the MWCs. Metribuzin was found in the drinking water at 10% (2/21) of the migrant worker camps. Metolachlor and cyanazine were each detected in 5% (1/21) of the MWCs.

Breaking the detection results down for synthetic pesticides by number of samples collected rather than the number of MWCs with detections alters the picture slightly. Atrazine was detected in 42% (18/43) of the immunoassay samples collected, while alachlor was detected in 40% (17/43). Simazine was present in 21% (9/43) of the immunoassay samples collected, while metribuzin was detected in 9% (4/43). Cyanazine and metolachlor were each detected in 5% (2/43) of the immunoassay samples collected.

Six percent (3/53) of the samples that contained a detectable quantity of a synthetic pesticide were over half the maximum contaminant level (MCL), EPA's SDWA enforcement standard. All three of these drinking water samples were provided from the same camp. Two of these samples contained alachlor and one contained atrazine.

One alachlor result from the aforementioned MWC was above the MCL. This June sample was measured at 2.15 ug/L using the immunoassay method. The September immunoassay analysis for the same MWC detected alachlor at 1.35 ug/L. Both immunoassay results were followed up by collecting a sample the next month and testing them for alachlor, using SDWA Method 507. Neither follow-up sample detected alachlor. Four other camps provided drinking water samples that had detections of alachlor in June and September using immunoassay analysis techniques, but demonstrated no detections for alachlor when using SDWA Method 507 in July and October.

There were eight drinking water analyses at four MWCs where immunoassay atrazine detections were followed up the following month by collecting a drinking water sample and analyzing it using SDWA Method 507. In each case, the values of atrazine identified using immunoassay techniques did not correspond closely with the results using Method 507. Using SDWA Method 507, one drinking water sample came within .01 ug/L of the atrazine MCL of 3.0 ug/L because deethylatrazine and atrazine combined reached a level of 2.99 ug/L. The atrazine MCL is calculated as the sum total of atrazine and atrazine metabolites. This detection occurred in drinking water collected from the same MWC that had the alachlor immunoassay detection which was over the MCL.

Synthetic pesticides that were present in the drinking water at MWCs in June usually were still present in September. Of the 29 drinking water samples collected from MWC taps in June that contained a detectable level of a synthetic pesticide, 24 (83%) detected the same contaminant from the same well in September. There were no synthetic pesticide detections at a MWC in September that did not already have a detection for the same synthetic pesticide in June.

As previously mentioned in the project description, well records were acquired from the WDNR for 14 of the MWC wells. Of the five MWC wells with reported casing depths of 50 feet or less, 100% (4/4) detected a synthetic pesticide in their drinking water sample. Of the nine wells with reported casing depths greater than 50 feet but less than or equal to 140 feet, 40% (2/5) detected a synthetic pesticide in their drinking water sample. For those wells with reported casing depths greater than 140 feet, 20% (1/5) detected a synthetic pesticide in their drinking water. Of the remaining seven wells at MWCs with unknown casing depths, 57% (4/7) detected a synthetic pesticide in their drinking water.

Nitrate and Copper Results

Eighty-six percent (18/21) of the MWCs provided a drinking water sample with a detectable quantity of nitrate. No samples collected registered a nitrate value that equaled or exceeded 20 mg/l. Nineteen percent (4/21) of the MWCs provided a drinking water sample that contained nitrate levels less than 20 mg/l but greater than or equal to EPA's MCL of 10 mg/L.

In all, 52% (11/21) of the MWCs provided a drinking water sample that contained nitrate levels greater than or equal to the preventive action limit (PAL) of 2 mg/L set under Wisconsin's Public Health Groundwater Quality Standards. Of the eleven MWCs that provided a drinking water sample that contained nitrate at or above 2.0 mg/L, 91% (10/11) also provided a drinking water sample that contained a detectable level of a pesticide. Of the ten MWCs providing a drinking water sample that did not contain nitrate at or above 2.0 mg/L, 90% (9/10) also provided no drinking water sample that contained a detectable level of a pesticide.

Nitrate levels less than 10 mg/L but greater than or equal to 5 mg/L were detected from drinking water samples provided from 23 % (5/21) of the MWCs. Ten percent (2/21) of the MWCs provided a drinking water sample that contained nitrate levels less than 5 mg/L but greater than or equal to the PAL of 2 mg/L.

Nitrate levels below 2 mg/L, but above the method detection limit, were detected from drinking water samples provided from 33% (7/21) of the MWCs. Fourteen percent (3/21) of the MWCs provided a drinking water sample that contained no detectable level of nitrate.

Breaking the detection results down for nitrate by number of samples collected in June and September alters the picture slightly. Nitrate was detected in 76% (32/42) of the drinking water samples collected in June and September. Fourteen percent (6/42) of the samples collected in June and September contained nitrate levels less than 20 mg/l but greater than or equal to 10 mg/l. Twenty-six percent (11/42) of the samples collected in June and September had nitrate levels less than 10 mg/l but greater than or equal to 5 mg/l. Ten percent (4/42) of the samples collected in

June and September had nitrate levels less than 5 mg/L but greater than or equal to 2 mg/L. Twenty-six percent (11/42) of the samples collected in June and September contained detectable levels of nitrate below 2 mg/l.

Of the five MWC wells with reported casing depths of 50 feet or less, 100% (4/4) contained nitrate in their drinking water sample at or above Wisconsin's preventive action limit (PAL) of 2 mg/L set under Wisconsin's Public Health Groundwater Quality Standards. Of the nine wells with reported casing depths greater than 50 feet but less than or equal to 140 feet, 20% (1/5) had nitrate detections at or above the PAL in their drinking water sample. For those wells with reported casing depths greater than 140 feet, 20% (1/5) had nitrate detections at or above the PAL in their drinking water. Of the remaining seven wells at the MWCs with unknown casing depths, 71% (5/7) had nitrate detections at or above the PAL in their drinking water.

For copper, there was no sample collected that was over the preventive action limit (PAL) of 130 ug/L set under Wisconsin's Public Health Groundwater Quality Standards.

Microbial Results

Sixty-seven percent (14/21) of the MWCs provided at least one drinking water sample that contained total coliform bacteria. Forty-two percent (9/21) of all the MWCs provided a drinking water sample that contained total coliform bacteria in their drinking water in more than one monthly sample. When the information is broken down by the total number of samples collected, 23% (29/127) of the samples contained total coliform bacteria. The number of detections for total coliforms at MWCs went from 0 detected in May to 10% (2/21) in June; peaked in July to 48% (10/21); reduced to 19% (4/21) in August; increased to 33% (7/21) in September; and stayed relatively stable at 29% (6/21) in October.

Twenty-seven of the 29 drinking water samples containing total coliforms were analyzed further to determine the species of bacteria causing the total coliform detection. None of the MWCs with a total coliform detection in more than one month detected the same species each time. Three bacterial genera were identified: *Citrobacter* (13/27), *Enterobacter* (12/27), and *Klebsiella* (2/27). Twelve of the 13 *Citrobacter* detections occurred in July and August. Ten of the 12 *Enterobacter* detections occurred in September and October. *Klebsiella* was only identified in September and October. *Escherichia coli* was not identified in any of the drinking water samples collected.

Viral analysis determined that 95% (20/21) of the MWCs provided at least one monthly drinking water sample that contained coliphages in the five months of sampling. Ninety-seven percent (35/36) of the detections occurred in the months of August and October. The August analyses showed coliphages present in drinking water samples collected from 81% (17/21) of the camps, and met laboratory quality assurance and quality control (QA/QC) procedures.

The coliphage analyses during the month of October indicated that coliphages were present in 86% (18/21) of the MWC samples, however, QA/QC concerns were reported by the laboratory

analysts. Negative control plates in at least one instance exhibited viral plaques, and serial ten-fold dilutions of stock viruses did not yield the anticipated $\log_{10}$ reductions during assay. However, EPA accepted the October analytical data based on the recommendation of the supervising virologist at the WSLH. His recommendation was based in part upon the observation that viral plaques observed in plates from the natural water samples exhibited significant differences in morphology and size, while control plates prepared from laboratory stocks exhibited essentially uniform plaques. The analytic laboratory implemented extensive additional control measures in order to eliminate cross contamination in subsequent assays.

Of the five MWC wells with reported casing depths of 50 feet or less, 0% (0/4) provided a drinking water sample analyzed as containing total coliforms. Of the nine wells with reported casing depths greater than 50 feet but less than or equal to 140 feet, 80% (4/5) provided a drinking water sample analyzed as containing total coliforms. For those wells with reported casing depths greater than 140 feet, 100% (5/5) provided a drinking water sample analyzed as containing total coliforms. Of the remaining seven wells at MWCs with unknown casing depths, 71% (5/7) provided a drinking water sample analyzed as containing total coliforms.

Conclusions

Using EPA's present model for determining health risk, no drinking water samples collected at the MWCs studied contained synthetic pesticide levels high enough to be considered a health risk, although atrazine levels at one camp bordered the MCL. Lower level detections of atrazine and alachlor in the drinking water, along with varying levels of nitrate, occurred fairly frequently at the MWCs. As EPA continues to evaluate the synergistic effects of chemicals, and their individual and combined effects on human development through endocrine system disruption, our view of the health risks may change. It is necessary for the EPA to continue studying actual human exposure levels to many different contaminants for this evaluation to be done properly. It makes sense to study these levels at locations which serve subpopulations that are exposed more frequently to synthetic pesticides, such as migrant laborers.

Nitrate levels in the drinking water were above the MCL of 10 mg/L at 14% of the MWCs. This level is high enough to cause a risk of methemoglobinemia for an infant who consumes the water, based on EPA's Ten-day Nitrate Health Advisory. For most, but not all of the MWCs, nitrate levels in the drinking water samples decreased throughout the months of the study. There was no significant amount of copper contributed from groundwater to cause a health risk at any of the MWCs studied.

This study suggests that shallow wells cased to depths of 50 feet or less are more susceptible to pesticide and nitrate contamination than wells cased more deeply. This study also shows a strong association between nitrate detection at or above 2.0 mg/L, and pesticide detection in the MWC drinking water.

Synthetic pesticide contaminant levels identified using immunoassay techniques did not correspond well with levels determined using SDWA Method 507. The differences in values using the two methods are most probably explained by the cross-reactivity to similar chemicals by

the immunoassay techniques. For example, the significant difference in values between the June immunoassay results and the July SDWA Method 507 results for alachlor could stem from the immunoassay's cross-reactivity with alachlor ESA, a metabolite of alachlor. It is possible that alachlor ESA was the culprit contaminant causing the detections of alachlor in the immunoassay results. SDWA Method 507 did not analyze for alachlor ESA, and demonstrated no detections of alachlor. Alachlor ESA was not specifically tested for in this study, and is not presently regulated in drinking water. Alachlor ESA is on EPA's Candidate List for future regulation development.

The data from the study suggests that there is a seasonality associated with total coliform detections at the MWCs. Detections occurred at greater rates in July, August, September and October than in May and June. This data suggests that PWSs that monitor annually early in the year may have total coliforms in their well later in the year that go undetected.

It is also clear that the same species of bacteria is not always responsible for continued total coliform detections in a small, public water system, like the MWCs. The genus most responsible for total coliform detections in July and August, *Citrobacter*, was replaced in September and October by *Enterobacter* and *Klebsiella.*

Of the 14 wells with well construction data, four out of five of the MWCs **without** a total coliform detection during the study period collected their drinking water samples from wells constructed to a depth of 50 feet or less.

Our research demonstrates that male-specific coliphages are not a good indicator for the presence of *E. coli* in drinking water. During July and October, viral detections occurred in the drinking water of many MWCs, yet there were no detections of *E. coli* at any of the MWCs during any month.

Coliphage viruses were intermittently present in almost all of the MWC wells, but there was no trend associated with when they would be detected. Coliphages were present in almost all wells studied regardless of their differences in depth and construction. These inconsistent results are compatible with the coliphage occurrence data of another researcher, Marilyn Yates, who presented her findings at the November 1997 Water Quality Conference in Denver, Colorado.

In summary, EPA found detections of pesticides in drinking water at MWCs, but not at levels of concern using EPA's current health risk model. Nitrate levels in the drinking water are high enough at some MWCs to be a health threat to infants. Total coliforms were detected at a significant number of MWC's drinking water, indicating a threat from fecal contamination, but *E. coli* was not identified in any MWC drinking water. Coliphages were intermittently present in almost all wells studied.