Thematic Area: Water Quality

Title: Impact of pesticide contamination of surface water sources in Grenada

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Agriculture has historically been a main stay of many Caribbean economies.Along with Latin America, the region currently produces approximately 60 percent of the world's coffee, 40 percent of its banana, 25 percent of its beans, 20 percent of its cocoa, and significant quantities of sugar, corn and other crops. Considerable amounts of pesticides are used for the production of these crops which can and do end up contaminating many surface and ground water sources. With little regulatory supervision in place and the use of inadequate agricultural practices, this poses a serious threat to the regions water sources, threatens the health of the population,and compromises the environmental quality for the continued development and reproduction of many other species.While large scale agriculture operations such as the sugarcane and banana industries have notably waned in Grenada and most other small Caribbean countries, this has been replaced by a significant increase in the number of small scale itinerant farming. One characteristic of such farming is the unregulated and improper use of pesticides.A biomonitoring study done between 2008 and 2011found evidence of human exposures to the following commonly used pesticidesin the Caribbean: organophosphates, carbamates, phenoxy acids, and chlorophenols.The results from this study underscores the urgent need for Grenada and other small Caribbean countriesto develop and implement sustainable management practices and measures which control the use and application of pesticides in the agricultural sector, thereby reducing the risk posed by these chemical to water sources.

Keywords: pesticides, biomonitoring, Caribbean, Grenada

Introduction

Agriculture has historically been a main stay of many Caribbean economies. Along with Latin America, the region currently produces approximately 60 percent of the world's coffee, 40 percent of its banana, 25 percent of its beans, 20 percent of its cocoa, and significant quantities of sugar, corn and other crops. Considerable amounts of pesticides are used for the production of these crops which can and do end up contaminating many surface and ground water sources.

Large scale agriculture operations such as the sugarcane and banana industries have notably waned in Grenada and most other small Caribbean countries, and been replaced by a significant increase in the number of small scale itinerant farming. In Grenada, small farmers undertake a significant percentage of the agriculture industry. The typical size of most lands used for agriculture is less than 5 hectares with nearly 75% of the farm sizes in Grenada being less than 0.8 ha in size. However, this represents less than 15% of the agricultural lands with approximately 50% of the agricultural lands being held in holdings varying from 1 to 10 ha. Many classes of pesticides have been authorized to be imported and used in Grenada. A FAO census of the Grenadian farmers found that use of pesticides by farmers ranged from 4% to 8% (**Table 1**).

One characteristic of such farming is the unregulated and improper use of pesticides. Surveys and reports coming from the Ministry of Agriculture field officers reveal that besides the use of pesticides in an unregulated and unmonitored manner, many farmers rely almost entirely on chemicals for pest controls, and that most farmers lack the necessary knowledge and guidance concerning proper pesticide usage.

One outcome of such improper use of pesticides is the threat it poses to freshwater ecosystems. Improper agricultural practices such as removal of vegetation which can lead to heavy sediment load of streams and farming too close to the banks or farming on slopes that are too steep lead to a reduction in the quality of surface waters. Additionally, improper chemical usage practices such as washing of gears and equipment laden with agricultural chemicals in streams can lead to the pollution of water sources that serve as the source of municipal water supply systems.

Table 1 Use of pesticides by Grenadian farmers based on FAO 2012 census.

Pesticide Type	**N = 9,345**	**%**
Fungicides	432	5%
Herbicides	637	7%
Insecticides	716	8%
Other pesticides	383	4%

Overview of water sources in Grenada

Grenada is reasonably well resourced with respect to fresh water.The island has 71 distinct watersheds of which the largest watershed, the Great River catchment comprises 4,521 ha whilst the smallest is the Crayfish catchment, 27 ha (**Figure 1**). Most of these watersheds have perennial flows, however, flows can drop significantly during the dry season. Of the 71 watershed catchments, 23 are utilized for water supply.

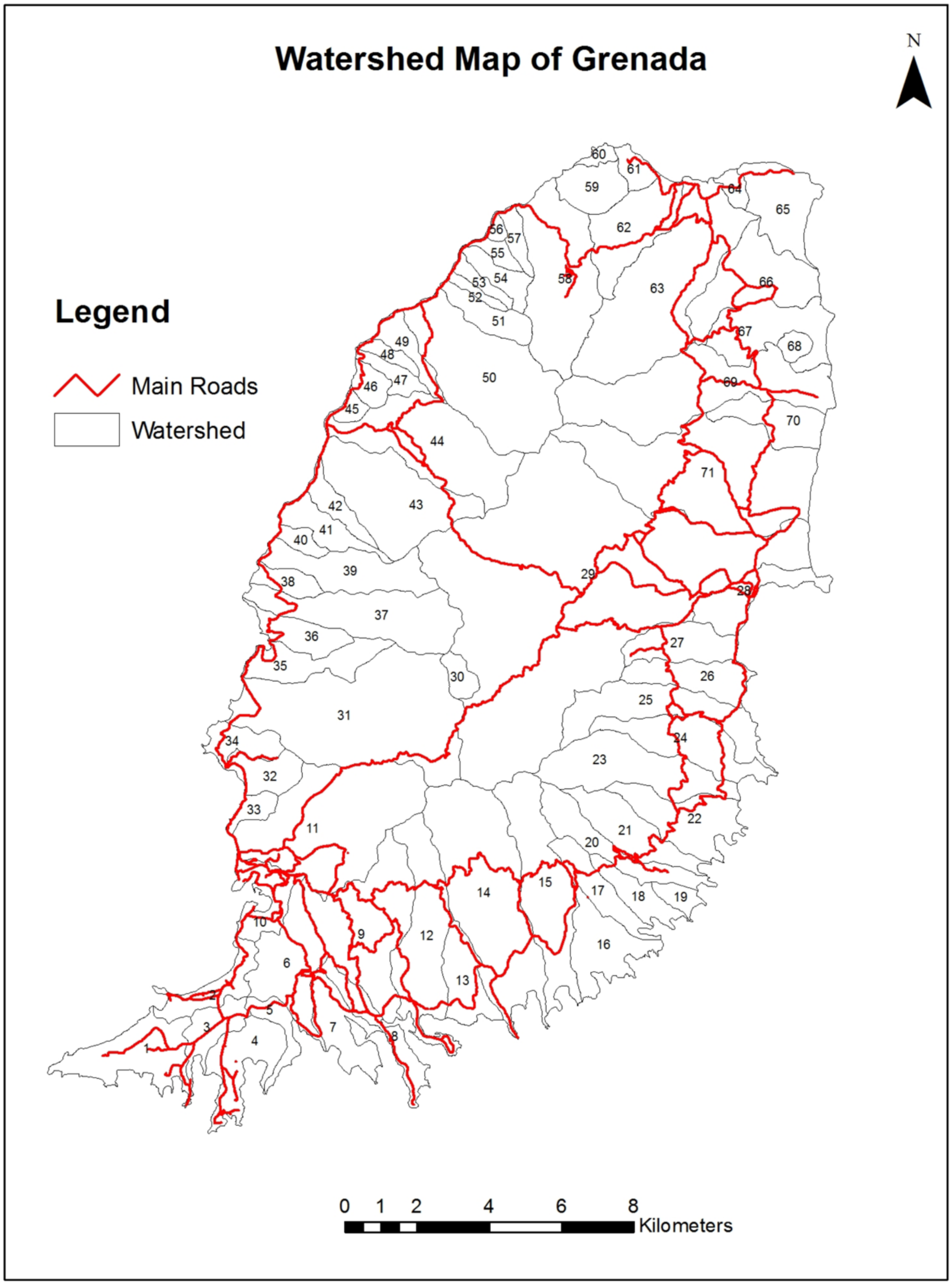

Figure 1. Watersheds in Grenada

Humans can become contaminated by pesticides by consuming water that has come from water catchment areas contaminated by pesticide runoffs. Pesticides are commonly used the Caribbean for both household and agricultural purposes. Of particular concern is exposure during pregnancy, as these compounds can cross the placental barrier and interfere with fetal development.A biomonitoring study done between 2008 and 2011 found evidence of human exposures to the following commonly used pesticides in Grenada and nine other Caribbean countries. The objective of this study was to evaluate exposure of pregnant women residing in 10 Caribbean countries to the following commonly used classes of pesticides in the Caribbean: organophosphates (OPs), carbamates, phenoxy acids, and chlorophenols.

While several large biomonitoring studies done in North America and elsewhere have found nearly ubiquitous exposure to many pesticides, similar studies in the Caribbean to evaluate human exposures to present-day pesticides have not yet been systematically conducted and published. As part of a Canadian Global Health Research Initiative's (GHRI) Teasdale-Corti grant program funded research initiative, a study was conducted to determine prenatal exposures to several toxicants including several commonly used pesticides.This paper reports on the findings for six organophosphate (OP) metabolites, the carbamate propoxur, the phenoxy acid 2,4-D, and several chlorophenol metabolites in pregnant women who live in the 10 Caribbean countries where this research study was successfully executed.

Methods

Samples were randomly selected from each Caribbean country and analyzed for the following metabolites: six OP dialkyl phosphates metabolites [dimethylphosphate (DMP), dimethylthiophosphate (DMTP), dimethyldithiophosphate (DMDTP), diethylphosphate (DEP), diethylthiophosphate (DETP) and diethyldithiophosphate (DEDTP)]; two carbamate metabolites [2-isopropoxyphenol (2-IPP) and carbofuranphenol]; one phenoxy acid 2,4-Dichlorophenoxyacetic acid (2,4-D); and five chlorophenols [2,4-dichlorophenol (DCP), 2,5-dichlorophenol (2,5-DCP), 2,4,5-trichlorophenol (TCP), 2,4,6-trichlorophenol (2,4,6-TCP), and pentachlorophenol (PCP)].

Results

From August 2008 to April 2011, 438 maternal urine samples were collected from pregnant women from 10 Caribbean countries and analyzed for several classes of pesticides (**Table 2**).

Organophosphates (OP) metabolites were consistently detected in ≥ 60% of the samples from Antigua and Barbuda, Bermuda, and Jamaica. For the carbamate metabolites, 2-IPP was detected in seven of the 10 Caribbean countries with a detection frequency around 30%, whereas carbofuranphenol was detected in only one sample. The detection frequency for the phenoxy acid 2,4-D ranged from 20% in Grenada to a high of 67% in Belize. Evidence of exposures to chlorophenol pesticides was also established with 2,4-DCP geometric means ranging from 0.52 μg/L in St. Lucia to a high of 1.68 μg/L in Bermuda. Several extreme concentrations of 2,5-DCP were detected in four Caribbean countries—Belize (1100 μg/L), Bermuda (870 μg/L), Jamaica (1300 μg/L), and St-Kitts and Nevis (1400 μg/L). 2,4,5-TCP, 2,4,6-TCP, and pentachlorophenol were rarely detected.

Discussion and Conclusions

Overall, the results of this study indicate that pregnant women in the English speaking Caribbean islands are exposed to modern pesticides. Many studies have established that these compounds and/or their metabolites can cross the placental barrier and are known to interfere with hormonal and neurological development, the immune system, and other physiological functions.

This initial exploratory biomonitoring study on the concentrations of pesticide chemicals or their metabolites in maternal urine samples taken from 10 Caribbean countries confirm that prenatal exposures to many neurotoxic and developmental toxicants are taking place throughout the Caribbean region. Generally, levels of pesticide metabolites in pregnant Caribbean women were comparable with those found in Canada and the U.S., however, multiple extreme values for some classes of pesticides such as chlorophenols were detected in several Caribbean countries. The significance of both low and high levels of exposure is compounded by the fact that any damage to the fetus' neurological and physiological development will be born out over the child's entire lifetime.

This study's biomonitoring data provides baseline data for future studies monitoring and evaluating changes in pesticide usage and exposure over time in this region of the world. Since pesticides and insecticides are widely used in tropical environments like the Caribbean, and given that the cumulative effect of chronic exposures on pregnant women and their offspring is strongly suggestive of being adverse, there is thus a strong need to monitor all water catchment zones so as to ensure that these are not contaminated. Finally, this study's data underscores the need for Caribbean public health authorities to become more aware of the potential routes of exposure and to utilize these pesticides more cautiously given the possible adverse effects of exposure to the most vulnerable members of their population.

Table 2 Summary of all pesticides results for the 10 Caribbeancountries who participated

Chemical Analyte	***ANU (N=40)***	**BLZ *(N=50)***	**BDA *(N=50)***	**DOM *(N=48)***	**GND *(N=51)***	**JAM *(N=47)***	**MON *(N=15)***	**SKN *(N=44)***	**SLU *(N=47)***	**SVG *(N=50)***	**CND**	**U.S.**
Organophosphorus metabolites (µg/L)	**ANU *(N=15)***	**BLZ *(N=15)***	**BDA *(N=15)***	**DOM *(N=15)***	**GND *(N=15)***	**JAM *(N=15)***	**MON *(N=15)***	**SKN *(N=15)***	**SLU *(N=15)***	**SVG *(N=15)***	**CND**	**U.S.**
Diethylphosphate (DEP)	4.47	1.56	1.95	1.31	1.72	2.07	N/A	2.52	1.21	1.10	2.20	13.5[a]
Diethylthiophosphate (DETP)	0.43	0.37	N/A	0.34	N/A	0.71	N/A	0.31	N/A	0.35	3.56[a]	2.57[a]
Diethyldithiophosphate (DEDTP)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.24[a]
Dimethylphosphate (DMP)	3.30	N/A	3.84	1.18	1.29	N/A	1.57	3.17	1.28	1.51	2.81	14.8[a]
Dimethylthiophosphate (DMTP)	1.85	N/A	2.26	N/A	0.78	0.96	1.26	1.39	0.67	1.29	1.81	2.06
Dimethyldithiophosphate (DMDTP)	N/A	N/A	0.42	N/A	N/A	0.27	N/A	N/A	N/A	N/A	5.46[a]	5.07[a]
Carbamates (µg/L)	**ANU *(N=15)***	**BLZ *(N=15)***	**BDA *(N=15)***	**DOM *(N=15)***	**GND *(N=15)***	**JAM *(N=15)***	**MON *(N=15)***	**SKN *(N=15)***	**SLU *(N=15)***	**SVG *(N=15)***	**CND**	**U.S.**
2-isopropoxyphenol	N/A	N/A	0.42	N/A	N/A	0.27	N/A	N/A	N/A	N/A	N/A	N/A
Phenoxy acids (µg/L)	**ANU *(N=15)***	**BLZ *(N=15)***	**BDA *(N=15)***	**DOM *(N=15)***	**GND *(N=15)***	**JAM *(N=15)***	**MON *(N=15)***	**SKN *(N=15)***	**SLU *(N=15)***	**SVG *(N=15)***	**CND**	**U.S.**
2,4-Dichlorophenoxyacetic acid (2,4-D)	N/A	0.33	0.22	0.24	N/A	0.19	N/A	N/A	N/A	0.17	N/A	N/A
Chlorophenols (µg/L)	**ANU *(N=15)***	**BLZ *(N=15)***	**BDA *(N=15)***	**DOM *(N=15)***	**GND *(N=15)***	**JAM *(N=15)***	**MON *(N=15)***	**SKN *(N=15)***	**SLU *(N=15)***	**SVG *(N=15)***	**CND**	**U.S.**
2,4-Dichlorophenol	0.83	0.63	1.68	0.42	0.80	0.93	0.96	1.07	0.36	0.52	N/A	N/A
2,5-Dichlorophenol	5.14	3.39	8.48	0.87	1.33	9.38	0.48	5.01	0.72	0.70	N/A	N/A
2,4,6-Triclorophenol	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13.3[a]
2,4,5-Trichlorophenol	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21.3[a]
Pyrethroids (µg/L)	**ANU *(N=22)***	**BLZ *(N=15)***	**BDA *(N=15)***	**DOM *(N=48)***	**GND *(N=50)***	**JAM *(N=45)***	**MON *(N=15)***	**SKN *(N=15)***	**SLU *(N=20)***	**SVG *(N=10)***	**CND**	**U.S.**
***cis*-DBCA**	0.11	0.03	0.03	0.01	0.04	0.07	N/A	0.02	0.04	0.02	0.09	NC
***cis*-DCCA**	0.50	0.07	0.24	0.10	0.22	0.11	0.14	0.24	0.17	0.20	0.08	0.80[a]
***trans*-DCCA**	1.28	0.14	0.63	0.23	0.65	0.22	0.31	0.58	0.42	0.46	0.19	1.50[a]
3-PBA	1.77	0.21	0.56	0.45	0.81	0.32	0.36	0.64	0.58	0.54	0.24	0.39
4-F-3-PBA	0.03	0.01	0.02	0.02	0.05	NC	NC	0.02	0.02	0.01	0.07[a]	N/A

N/A if less than 40% of samples are above LOD.

NC Not calculated (proportion of results below LOD was too high to provide a valid result)

[#] The Canadian Hg and Pb results based on the Canadian Health Measures Survey (CHMS) Cycle 1, 2007-2009 females ages 20-39. The U.S. Hg and Pb results based on the NHANES 2009-2010 females all ages results.

[a] The 95th percentile geometric mean.