WATER CONTAMINATION WITH TOXIC CHEMICALS AND HEALTH EFFECTS

The main source of drinking water pollution can be attributed to environmental contamination with toxic chemicals, discharge of untreated waste, and dumping of industrial effluents. It is a generally accepted fact that the main problem of chemical discharge into the water sources mainly groundwater.

GROUNDWATER CONTAMINATION

⇨ Many areas of groundwater and surface water are now contaminated with heavy metals, POPs (persistent organic pollutants), and nutrients that have an adverse affect on health.
⇨ Ground water can be contaminated through various sources and some of these are mentioned below:

@=1=Contamination of the environment and dispersion trough infiltration, evaporation, winds, and rain, containing pesticides contaminate the water.

@=2=Groundwater is susceptible to contamination, as pesticides are mobile in the soil. It is a matter of concern as these chemicals are persistent in the soil and water.

@=3=Leechate from landfill sites is a major contaminating source: SEE MY REPORT ON THE ORDOT DUMPSITE

@=4=There are more than 100 Ground Water Wells in this part of the island (North). Some of these wells are connected trough conduits that flow out as springs or seeps along Tumon Bay (South). Studies conducted in 2001 by the Environmental Protection Agency (EPA) of Guam, on the spring waters that discharged from the northern lens acquifer in Guam, reported unusually high levels of Arsenic.

@=5=Where toxic chemicals are present in high concentrations in the environment, *groundwater gets contaminated* and this leads to the *chemical contamination of drinking water.*

Chemicals in drinking water

Chemicals in water can be both naturally occurring or introduced by human interference and can have serious health effects.

1. Petrochemicals.

Petrochemicals contaminate the groundwater from underground petroleum storage tanks.

Petrochemicals are chemical products made from raw materials of petroleum (hydrocarbon) origin.

The two main classes of raw materials are olefins (including ethylene and propylene) and aromatics (including *benzene and xylene* isomers), both of which are produced in very large quantities, mainly by the steam cracking and catalytic reforming of refinery hydrocarbons. From these basic building blocks are made a very wide range of raw materials used in industry - plastics, resins, fibres, *solvents*, detergents, etc.

GUAM: *VOLATILE ORGANIC COMPOUND (VOC)* IN THE ENVIRONMENT:
A. Trichloroethylene (TCE):

Federal Agency for Toxic Substances & Disease Registry (ATSDR)
TCE: sites, dates, and concentrations/comparison values (CVs).

Groundwater from Downgradient Wells of Each Site

This area (Yigo) has over 100 interconnected wells

❒ **GUAM, YIGO –** (SITE NO. 33)
Drum Storage Area. No.2-Operable Unit. Main Base:

Active drum storage area for asphalt, paints, oil, tar, & contaminated soil from underground storage tank removals.

PCE: concentrations *"above"* the ATSDR *drinking water* CV.

❒ **GUAM, MARBO –** (SITE NO. 37)
War Dog Borrow Pit-Operable Unit. MARBO Annex: is an abandoned quarry.

Its contents and dates of operation are unknown.

TCE : concentrations *"above"* the ATSDR *drinking water* CV

❒ **GUAM, MARBO –** (SITE NO. 22)
Waste Pile No.6 (formerly Landfill No. 27)-Operable Unit.MARBO Annex: contains construction debris.

***Dates of operation are unknown*.**

PCE: concentration *"above"* the ATSDR *"drinking water"* CV.

❒ **GUAM, YIGO –** (SITE NO. 2)
Landfill No.2/Landfill No.4/Landfill No.5 (4 & 5 are contained within 2)-Operable Units. Main Base: was used from 1947 to 1975, with a small area active until 1982. Materials disposed of at this site include ***petroleum, oil, lubricants, solvents, pesticides***, ferrous metal, construction debris, and unexploded ordinance.

TCE: concentrations *"above"* the ATSDR *drinking water* CV

❒ **GUAM, YIGO –** (SITE NO. 8)
Landfill No. 10/Landfill No. 11/Landfill No. 12. Operable Units. Main Base. LF-10: used from the early to mid-1950 to dispose of asphalt wastes, scrap metals, empty 55-gallon drums, sanitary wastes, construction debris, occasional waste POL, and solvents. LF-11: used in the early 1950s as a disposal area for asphaltic material, empty 55-gallon drums, and construction debris. LF-12: used in the late 1950s to dispose of sanitary trash and asphaltic wastes.

PCE: concentrations *"above"* the ATSDR *drinking water* CV.

❒ **GUAM, MARBO –** (SITE NO. 38)
MARBO Laundry Facility-Operable Unit. MARBO Annex

PCE: concentrations *"above"* the ATSDR *drinking water* CV.

EXPOSURE

The US Air Force began uses TCE, an industrial solvent, to degrease airplane parts.

1. Tetrachloroethylene (TCE) is a synthetic chemical that is widely used for metal-degreasing operations. Other names for tetrachloroethylene include perchloroethylene, PCE, pert, tetrachloroethene, perclene, and perchlor.

2. TCE enters the environment mostly by evaporating into the air during use. ***It gets into surface water supplies and the soil during disposal of sewage sludge and when leaking from underground storage tanks.***

3. Tetrachloroethylene may also get into the air, soil, ***or water by leaking or evaporating from storage and waste sites.***

4. TCE can stay in the air for several months before is brought back down to the soil and *water* by rain.

5. ***Much of the tetrachloroethylene that gets into water*** and soil will evaporate into the air. However, because tetrachloroethylene can travel through soils quite easily, ***it can get into underground drinking water supplies. If it gets into underground water, it may stay there for many months.***

6. ***TCE can enter the body when people breathe air containing it, or when they drink water***

HEALTH EFFECTS

A. Statements by Federal Authorities:

- **US Senators--Hillary Rodham Clinton, Barbara Boxer, Christopher J. Dodd, Frank Lautenberg, Joseph I. Lieberman, Gordon Smith,** and **Ron Wyden** in written appeal to EPA for better public protection against TCE:
  "TCE...is known to cause cancer and damage the nervous and immune systems. Children and seniors are especially vulnerable to TCE's toxic effects... Today, thousands of Americans may be exposed to unhealthful levels of TCE."

- **Walter Mugdan, Director,** Division of Environmental Planning and Protection, US EPA in Vapor Intrusion, The Next Big Thing, August, 2006**:**
  "The major implication of the new findings is, of course, that human exposures at potentially dangerous levels may have occurred for years or decades, even after a site was recognized and (as we thought), satisfactorily addressed. We may presume that our relative ignorance in this arena will unfortunately have contributed to some number of additional cancers or other illnesses that could have been prevented."

B. Studies

Studies by the National Research Council, sponsored by the U.S. Department of Defense, the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the National Aeronautics and Space Administration, shows that TCE (Trichloroethylene) is:

1. Nephrotoxic
2. Nephrocarcinogenic
3. Cardiac teratogenesis
4. Cause of infertility in males and females
5. Cause of impaired fetal growth.

GUAM: *VOLATILE ORGANIC COMPOUND (VOC)* IN THE ENVIRONMENT: B. BTEX (benzene, toluene, ethylbenzene, and xylenes)

Federal Agency for Toxic Substances & Disease Registry (ATSDR)
BTEX: sites, dates, and concentrations/comparison values (CVs).

Groundwater from Downgradient Wells of Each Site

❒ **GUAM, YIGO –** (SITE NO. 26)
Fire Training Area No.2. Main Base: used between 1958 and 1988

BTEX: concentrations "above" CVs---- up to: 7,200 ppb

EXPOSURE

a) Benzene, toluene, ethylbenzene, and xylenes (BTEX) frequently occur together at hazardous waste sites. The four chemicals are volatile and have solvent properties.

b) BTEX compounds are among the most acutely toxic and the most mobile in soil and groundwater, with the potential to move through soil and contaminate ground water, and their vapors are highly flammable and explosive.

c) BTEX compounds can pose a drinking water hazard when they accumulate in ground water.

HEALTH EFFECTS

BTEX compounds are well absorbed, distribute to lipid-rich and vascular tissues such as the brain, bone marrow, and body fat due to their lipophilicity.

A. Chronic potential hazards include harmful effects to the:

- Liver
- Kidneys
- Heart
- Lungs
- Nervous System, including neurological impairment
- Anemia, with subsequent manifestation of Acute Myelogenous Leukemia.

B. Acute hazards include:

Potential acute toxicity to aquatic life in the water column, as well as potential inhalation hazards.

2. Arsenic.

Arsenic occurs naturally or is possibly aggrevated by over powering aquifers and by phosphorus from fertilizers. High concentrations of arsenic in water can have an adverse effect on health.A few years back, high concentrations of this element was found in drinking water in six districts in West Bengal. A majority of people in the area was found suffering from arsenic skin lesions. It was felt that arsenic contamination in the groundwater was due to natural causes. The government is trying to provide an alternative drinking water source and a method through which the arsenic content from water can be removed.

GUAM: *ARSENIC* IN THE ENVIRONMENT

Federal Agency for Toxic Substances & Disease Registry (ATSDR)
Arsenic: sites, dates, and concentrations/comparison values (CVs).

***Shallow Subsurface Soil*:**
ATSDR: average level of Arsenic in soil: 3-4 ppm.

- **GUAM, YIGO –** (SITE NO. 27)
  Hazardous Waste Storage Area No.1. Main Base: beginning in 1950 and continuing through the 1970s, petroleum, oil, lubricants, and solvents were stored. From the late 1970s to 1983 was used to store hazardous wastes.

  Arsenic: concentration *"above"* CVs----up to 201 ppm

- **GUAM, YIGO –** (SITE NO. 28)
  Chemical Storage Area No.1. Main Base: in the early 1970s, the site may have been used for the disposal of waste petroleum, oils, lubricants, and chlorinated solvents. About 70% of the site is filled material covered with vegetative cover.

  Arsenic: concentrations *"above"*CVs----up to 15 ppm

- **GUAM, YIGO –** (SITE NO. 4)
  Landfill No.6. Main Base: operated from 1953 to 1954.

***Twenty surface soil samples were analyzed. Results*--Arsenic: concentrations "above" CVs for a child**

EXPOSURE

The scientific literature about the toxicity of arsenic is extensive, containing a large number of studies of exposed human populations, in whom the main route of exposure is oral. These studies have identified effects on virtually every organ or tissue evaluated.

HEALTH EFFECTS

A. CANCER

The Department of Health and Human Services (DHHS): concluded that inorganic arsenic is a human carcinogen.
The Environmental Protection Agency (EPA): determined that inorganic arsenic is a human

carcinogen by the inhalation and oral routes, and has assigned it the cancer classification, Group A.
*The International Agency for Research on Cancer (IARC)***:** cites sufficient evidence of a relationship between exposure to arsenic and human cancer. The IARC classification of arsenic is Group 1.

Main types of cancer related to arsenic exposure:

- **Lung Cancer**: there is clear evidence from studies in humans that exposure to inorganic arsenic by either the inhalation or oral routes increases the risk of cancer. Numerous studies have reported an increased risk of lung cancer.
- **Skin Cancer**: there is convincing evidence from a large number of epidemiological studies and case reports that ingestion of inorganic arsenic increases the risk of developing skin cancer. The most common tumors seen are squamous cell carcinomas, which may develop from the hyperkeratotic warts or corns commonly seen as a dermal effect of oral inorganic arsenic exposure.
- **Bladder Cancer**: there is increasing evidence that long-term exposure to arsenic can result in the development of bladder cancer, with transitional cell cancers being the most prevalent.
- **Tranplacental Cancer**: a recent study in mice reported that arsenic could function as a complete transplacental carcinogen, resulting in tumors in the offspring of exposed animals.

B. CARDIOVASCULAR

A large number of studies in humans have reported cardiovascular effects following oral exposure to inorganic arsenic compounds. The cardiac effects of arsenic exposure are numerous, and include:

a. Altered Myocardial Depolarization
b. Cardiac Arrhythmias
c. Ischemic Heart Disease.

These effects have been seen after acute and long-term exposure to inorganic arsenic in the environment. Chronic exposure to inorganic arsenic has also been shown to lead to effects on the vascular system. The most dramatic of these effects is “Blackfoot Disease”, a disease characterized by a progressive loss of circulation in the hands and feet, leading ultimately to necrosis and gangrene. Arsenic exposure has also been associated with an increased incidence of cerebrovascular and microvascular diseases and ischemic heart disease. Other vascular effects are common in areas with arsenic exposures, include such severe effects as increases in the incidences of Raynaud's disease and of cyanosis of fingers and toes as well as hypertension, thickening and vascular occlusion of blood vessels, and other unspecified cardiovascular conditions.

C. NEUROLOGICAL

1. Encephalopathy.
2. Peripheral Neuropathy.
3. Children: decreases in intelligence scores.

D. SKIN

a. Hyperkeratinization
b. Hyperpigmentation.

3. Lead.

Pipes, fittings, solder, and the service connections of some household plumbing systems contain lead that contaminates the drinking water source.

GUAM: *LEAD* IN THE ENVIRONMENT

Federal Agency for Toxic Substances & Disease Registry (ATSDR)
Lead: sites, dates, and concentrations/comparison values (CVs).

A. *Shallow Subsurface Soil*

EPA: Uncontaminated soil-concentrations of less than 50 ppm. Soil cleanup level-400 ppm

❒ **GUAM, YIGO** – (SITE NO. 10).
Landfill No.14. Main base: contains concrete debris and construction debris.

Lead: concentrations *"above"* CVs----up to 40,000 ppm

❒ **GUAM, MARBO** – (SITE NO. 22)
Waste Pile No. 6 (formerly known as Landfill No. 27). MARBO Annex: contains construction debris.

Dates of operation are unknown.

Lead : concentrations *"above"* CVs ---- up to 6,500 ppm

❒ **GUAM, MARBO** – (SITE NO. 24)
Landfill No.29. MARBO Annex: is littered with household debris and garbage.

Dates of operation are unknown.

Lead: concentrations "above" CVs ---- up to 1,100 ppm

❒ **GUAM, YIGO** – (SITE NO. 28)
Chemical Storage Area No. 1. Main Base: in the early 1970s, the site was used for the disposal of waste petroleum, oils, lubricants, and chlorinated solvents.

About 70% of the site is filled material covered with vegetative cover.

Lead: concentrations *"above"* CVs ---- up to 770 ppm

❒ **GUAM, NORTHWEST FIELD** – (SITE NO. 31).
Chemical Storage Area No. 4. Northwest Field: waste oils and solvents were stored at this site.

Lead: concentrations *"above"* CVs --- up to 3,100 ppm

❒ **GUAM, YIGO** – (SITE NO. 27)**.**
Hazardous Waste Storage Area No. 1. Main Base: beginning in 1950 and continuing through the 1970s, petroleum, oil, lubricants, and solvents were stored. From the late 1970s to 1983 was used to store hazardous wastes.

Lead : concentration *"above"* CVs----up to 8,600 ppm

❒ **GUAM: NORTHWEST FIELD** - (SITE NO. 16).
Landfill No. 21. Northwest Field: operated as a sanitary trash disposal site.

Lead: concentrations *"above"* CVs----up to 16,000 ppm

❒ **GUAM, YIGO** – (SITE NO. 5).
Landfill No. 7. Main Base.

Lead: concentrations *"above"* CVs

❒ **GUAM, MARBO** – (SITE NO. 38)
MARBO Laundry Facility. MARBO Annex.

Lead: concentrations *"above"* CVs ---- up to 15,700 ppm

B. Groundwater from Downgradient Wells of Each Site

❒ **GUAM, YIGO –** (SITE NO. 1)
Landfill No. 1. Operable Unit. Main Base: opened in 1945 and continues to be used today. Materials disposed of include waste petroleum, oil, lubricants (POL), solvents, ferrous metal, construction debris, and pesticides

Lead: concentration*"above" drinking water* comparison values (CVs)

❒ **GUAM, MARBO –** (SITE NO. 24)
Landfill No. 29 (LF-29). OU: MARBO Annex. LF-29 is littered with household debris and garbage.

Dates of operation are unknown.

Lead: present/concentration not-specified

EXPOSURE

A common source of lead contamination are landfills that contain waste of lead-containing products (i.e. ammunition in military bases, or waste and debris of certain activities)

A. Contamination of the Environment

1. Once lead falls onto soil, it sticks strongly to soil particles and remains in the upper layer of soil, and part of it may enter rivers, lakes, and streams when soil particles are moved by rainwater.
2. Sources of lead in dust, soil, and groundwater include lead that falls to the ground from the air. Once lead that gets into the atmosphere, may travel long distances if the lead particles are very small
3. Lead may remain stuck to soil particles or sediment in water for many years.
4. The levels of lead may build up in plants and animals from areas where air, water, or soil are contaminated with lead.
5. If animals eat contaminated plants or animals, most of the lead that they eat will pass through their bodies.

B. Exposure of the population to lead

a) People living near hazardous waste sites are exposed to lead and chemicals that contain lead by breathing air, drinking water, eating foods, or swallowing dust or dirt that contain lead.

b) People may be exposed to lead by eating food, drinking water, or breathing in or swallowing airborne dust and dirt.

c) Leafy fresh vegetables may have lead-containing dust on them. Children may be exposed to lead by hand-to-mouth contact after exposure to lead-containing soil or dust.

d) Some of the lead that enters the human body comes from breathing in dust or chemicals that contain lead. Once this lead gets into the lungs, it goes quickly to other parts of the body in the blood.

e) Lead can also enter the body by swallowing food or drinking liquids that contain it.

f) Dust and soil that contain lead may get on the skin.

g) Shortly after lead gets into the body, it travels in the blood to the "soft tissues" and organs (such as the liver, kidneys, lungs, brain, spleen, muscles, and heart).

h) After several weeks, most of the lead moves into the bones and teeth. Some of the lead can stay in the bones for decades; however, some lead can leave the bones and reenter the blood and organs under certain circumstances (e.g., during pregnancy and periods of breast-feeding, after a bone is broken, and during advancing age).

HEALTH EFFECTS

- An enormous amount of information is available on the health effects of lead on human health. In fact, the toxic effects of lead have been known for centuries, but the discovery in the past few decades that levels of exposure resulting in relatively low levels of lead in blood associated with adverse effects in the developing organism is a matter of great concern.

- The most sensitive targets for lead toxicity are the developing nervous system, the hematological and cardiovascular systems, and the kidney. However, due to the multi-modes of action of lead in biological systems may affect any organ in the body, including:

    1. Encephalitis, Parkinson's Disease, Multiple Sclerosis, Myelopathy (spinal cord pathology), Epilepsy, Peripheral Neuropathies, Seizures.

    2. Memory Loss (long term), Attention Deficit Disorder, Autism, Schizophrenia, Concentration Loss, Emotional Instability, Hallucinations, Depression, Dyslexia, Behavioral Disorders, Hyperactivity, Learning Disability.

    3. Arthritis (rheumatoid and osteo), Gout, Muscular Dystrophy, Joint Pain, Cartilage Destruction.

    4. Nephritis, Renal Dysfunction

5. Cardiovascular Disease, Anemia, Hypertension.
6. Adrenal Insufficiency, Hypothyroidism.
7. Stillbirths, Sterility, Infertility, Sudden Infant Death Syndrome.
8. Liver Dysfunction.
9. Deafness, Blindness.
10. Immune Suppression**.**

Recommendations of the federal government to protect the health of the community:

- CDC:

Recommends that states develop a plan to find children who may be exposed to lead and have their blood tested for lead. CDC recommends that the states test children: at ages 1 and 2 years; at ages 3-6 years if they have never been tested for lead; and if they receive services from public assistance programs for the poor.

- EPA :

Developed regulations limiting lead in drinking water to 0.015 milligrams per liter (mg/L), although the goal is that drinking water be free of lead.

- The 1988 Lead Contamination Control Act:

The Control Act requires the Consumer Product Safety Commission, EPA, and the states:
That drinking water in schools must be tested for lead, and the sources of lead in this water must be removed.

Pesticides.

GUAM: *PESTICIDES* IN THE ENVIRONMENT

Federal Agency for Toxic Substances & Disease Registry (ATSDR)

Pesticides: sites, dates, & concentrations/comparison values (CVs).

ATSDR produced the: "Report of the United States Agency for Toxic Substances and Diseases Registry, Public Health Assessment. Andersen Air Force Base, Yigo, Guam. EPA Facility ID: GU 6571999519. January 4, 2002. Prepared by Federal Facilities Branch, Division of Health Assessment and Consultation, Agency for Toxic Substances and Disease Registry (ATSDR). **(1)**

The sources for ATSDR's report, are:

a) Andersen Air Force Base. Yigo, Guam: 1998b, 1998c, 1998d;

b) Andersen Air Force. Yigo, Guam. 1999c, 1999d, 1999e, 1999f, 1999g;

c) Anderson Air force Base, Yigo, Guam. 2000b, 2000c.

d) United States Air Force (USAF):1992a, 1996, 1997, 2000.

e) SAIC 1991

f) Anderson Air Force Base. Yigo, Guam. EPA ID #: GU-6571999519. OU 07. December 2003.

Groundwater Wells:

❒ **GUAM, MARBO –** (SITE NO. 24)
Landfill No.29-Operable Unit. MARBO Annex: is littered with household debris and garbage.

Dates of operation are unknown.

Pesticides: present/concentrations not-specified

❒ **GUAM, YIGO –** (SITE NO. 26)
Fire Training Area No.2-Operable Unit. Main Base: used between 1958 and 1988**.**

Pesticides: present at levels *"above"* CVs

❒ **GUAM, YIGO –** (SITE NO. 8)
Landfills No.10/Landfill No.11/Landfill No.12-Operable Units. Main Base. LF-10: used from the early to mid-1950s to dispose of asphalt wastes, scrap metals, empty 55-gallon drums, sanitary wastes, construction debris, ***petroleum, oil, lubricants, and solvents***. LF-11: was used in the early 1950s as a disposal area for asphaltic material, empty 55-gallon drums, and construction debris. LF-12: was used in the late 1950s to dispose of sanitary trash and small quantities of asphaltic wastes.

Pesticides: present/concentrations not-specified

There are more than 865 active ingredients registered as pesticides, which are formulated into thousands of pesticide products that are available in the marketplace. About 350 pesticides are used on the foods we eat, and to protect our homes and pets.

EXPOSURE

- Studies show that only 5% of pesticides reach target weeds. The rest, (95 % of the pesticides) runs off into water or dissipates in the air. Drift from landscaping can range from 12 feet **to 14.5 miles.** Guam is 30 miles x 10 miles.

- Pesticides can be absorbed through the skin, swallowed or inhaled. Pesticides often stray from their point of application to settle on neighbors' properties, clotheslines, pools, toys and furniture.

- Children and pets often track pesticide residues into the house.

- Effects that are more serious appear to be produced by direct inhalation of pesticide sprays than by absorption or ingestion of toxins.

- Because safety testing has not been adequate, current pesticide applications are essentially a giant experiment using the general public.

- In the US, it is a violation of federal law to state that the use of pesticides is safe, because pesticides are toxic by definition.

HEALTH EFFECTS

A. Short/Single and Intermediate Exposure

? Neurotoxicity

B. Long-term exposure

? Cancer

? Birth Defects

? Genotoxicity

? Hormone Disruption (development, growth, reproduction, and behavior)

Human Health Risk Assessment and the Law:
Federal law requires detailed evaluation of pesticides to protect human health and the environment. In 1996, Congress made significant changes to strengthen pesticide laws through the Food Quality Protection Act (FQPA). Many of these changes are key elements of the current risk assessment process. FQPA required that EPA consider:

- A New Safety Standard: FQPA strengthened the safety standard that pesticides must meet before being approved for use. EPA must ensure with a reasonable certainty that no harm will result from the legal uses of the pesticide.

- Exposure from All Sources: In evaluating a pesticide, EPA must estimate the combined risk from that pesticide from all non-occupational sources, such as:
  Food Sources
  Drinking Water Sources
  Residential Sources

- Cumulative Risk: EPA is required to evaluate pesticides in light of similar toxic effects that

different pesticides may share, or “a common mechanism of toxicity”. At this time, EPA is developing a methodology for this type of assessment.

- Special Sensitivity of Children to Pesticides: EPA must ascertain whether there is an increased susceptibility from exposure to the pesticide to infants and children. EPA must build an additional 10-fold safety factor into risk assessments to ensure the protection of infants and children, unless it is determined that a lesser margin of safety will be safe for infants and children.

4. Other heavy metals.

These contaminants come from mining waste and tailings, landfills, or hazardous waste dumps.

5. Chlorinated solvents.

Metal and plastic effluents, fabric cleaning, electronic and aircraft manufacturing are often discharged and contaminate groundwater.

Synthetic organics.

Many of the 100 000 synthetic compounds in use today are found in the aquatic environment and accumulate in the food chain. POPs or Persistent organic pollutants, represent the most harmful element for the ecosystem and for human health, for example, industrial chemicals and agricultural pesticides.

This is a Research Summary of Dr. Luis Szyfres, MD, MPH