PQRA On Whin Valley Rice Field In Shama, Ghana

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Introduction and Background

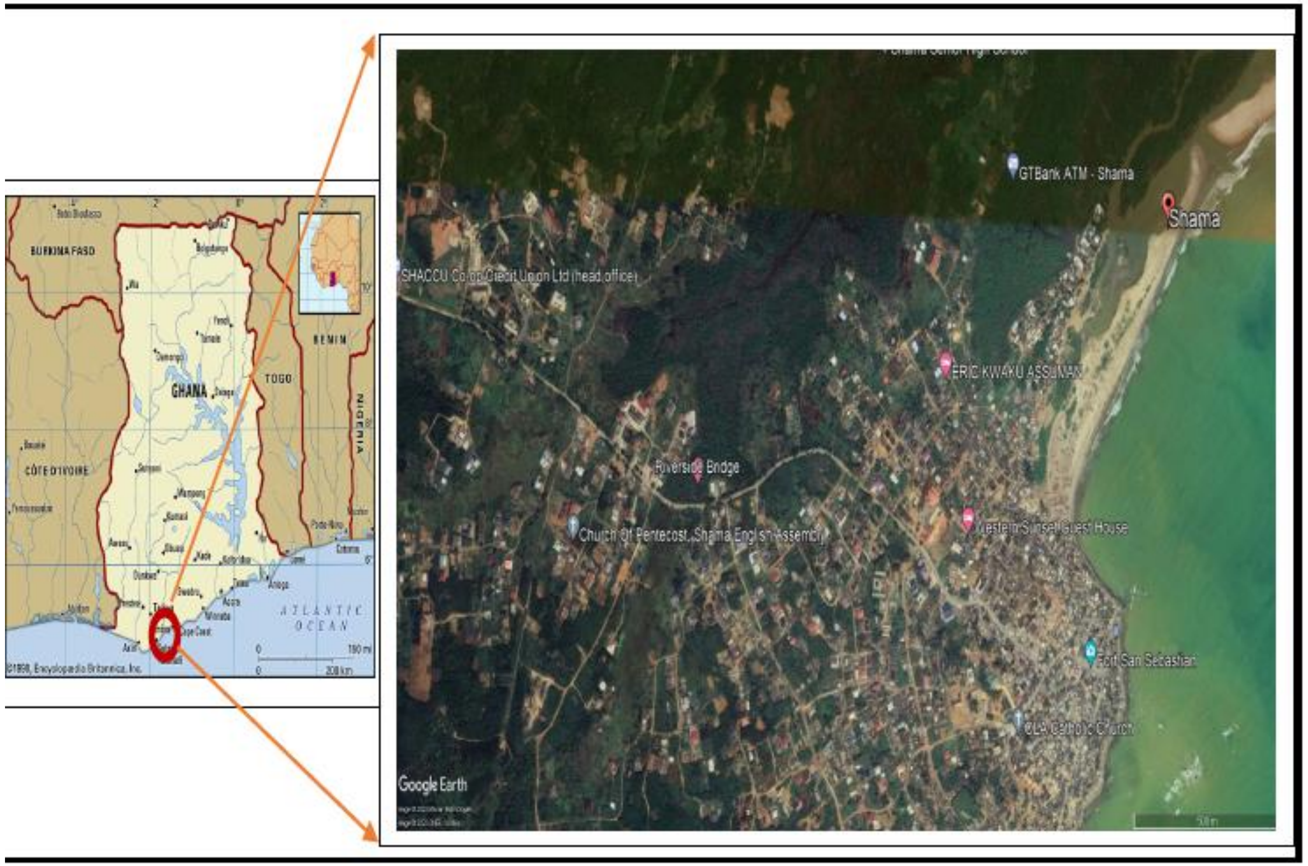
- Global food demand has led to intensified agricultural practices.
- These practices contribute to environmental contamination, such as soil heavy metal accumulation.
- Agriculture is key to food security and economic growth in Ghana.
- Shama District is an agrarian region where rice farming is a major activity.

Introduction and Background Cont'd.

- Soil contamination is a growing concern, affecting both crop quality and human health.
- Rice is a staple food in Ghana; high consumption increases exposure risk.
- Understanding contamination levels helps to protect public health.
- Data from this study can guide policy recommendations and sustainable agricultural practices.

Shama District Overview

- Located in the Western Region of Ghana
- One of the 14 districts in the region
- Population: 88,414 inhabitants with 42% engaged in agriculture.
- Department of Agriculture
- Significance of rice farming in the economy.



Agrochemical Use and Proliferation

- Planting for Food and Jobs(PFJ) program
- Increased reliance on fertilizers and pesticides
- Heavy metal contamination from agrochemicals
- Concerns over sustainable farming practices

Illegal Mining and Its Impact

- Heavy metal pollution from illegal mining
- Unregulated use of mercury in gold extraction
- Contaminants entering rice fields through irrigation
- Bioaccumulation and heavy metals in crops

Policies on Illegal Mining (Galamsey)

- Past efforts: Operation Fight Illegal Mining, Operation Vanguard, Operation Halt.
- Challenges in enforcement and effectiveness
- Continued contamination despite interventions

Objectives of the Study

1. Assess heavy metal contamination in Shama rice fields
2. Evaluate exposure risks for farmers
3. Provide scientific evidence for policymakers and farmers
4. Support informed decisions for sustainable farming

Preliminary Quantitative Risk Assessment(PQRA)

- Preliminary Quantitative Risk Assessment (PQRA) is an initial evaluation framework used to estimate the potential risk posed by environmental contaminants to human health.
- Key factors: Mining residue & Agrochemical contamination
- Human Health Risk Assessment

Methods

- Sampling Technique: Random sampling
- Sampling Depth: Ranged between 0.0-0.5m
- Sample Size: Six(6) samples for a 300-acre field
- Lab Analysis: Flow Injection and Flame Atomic Absorption Spectroscopy

Laboratory Analysis-Contaminant Concentrations

Table 1. Concentrations of heavy metals

Sample ID	Depth (m)	Pb(mg/kg	Cd(mg/kg)	As(mg/kg)	Hg(mg/kg)
BH R1-001	0.0-0.3	24.90	1.76	2.63	1.44
BH R2-002	0.3-0.5	33.40	0.97	3.40	2.80
BH R3-003	0.0-0.5	22.40	1.28	3.90	3.00
BH R4-004	0.1-0.4	33.90	2.41	4.90	3.20
BH R5-005	0.0-0.4	17.60	1.21	6.30	4.90
BH R6 -006	0.0-0.2	41.10	2.86	9.20	8.00

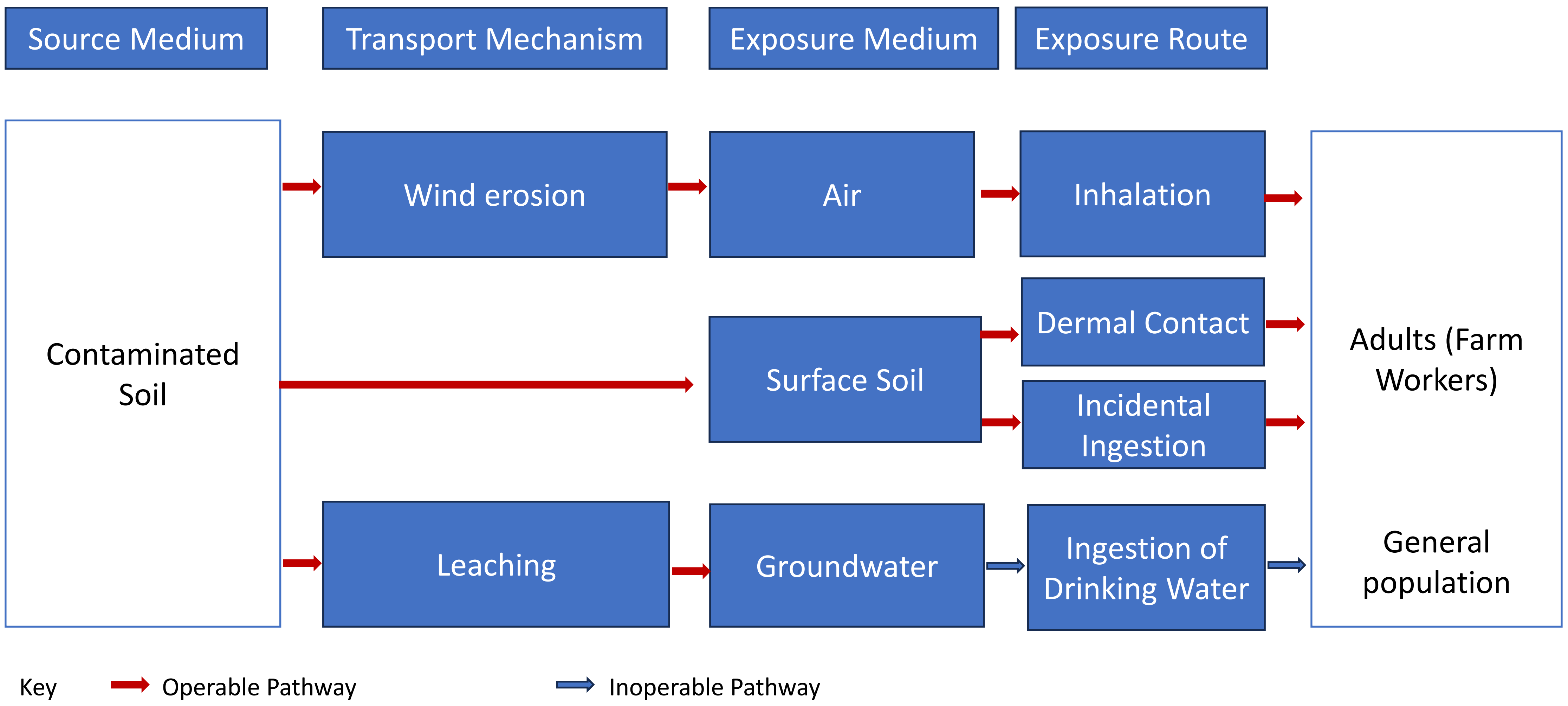
Problem Formulation

- Table 2. Identification of Contaminants of Potential Concern

Chemical Name/CASRN	Maximum Concentration of CoPC in soil(mg/kg)	Generic Guideline Concentration(mg/kg dry weight) Agricultural	Soil Quality Guideline for Human Health(SQGhh)	Does Contaminant exceed SQGhh?	Carry out Risk Assessment?
Arsenic 7440-38-2	9.20	12.00	12.00	No	No
Cadmium 7440-43-9	2.86	1.40	1.40	Yes	Yes
Lead 7439-92-1	41.10	70.00	140.00	No	No
Mercury 7439-97-6	8.00	6.60	6.60	Yes	Yes

Conceptual Site Model

Figure 1: Conceptual Site Model showing Exposure Pathways



Toxicity Assessment for the Contaminants of Potential Concern(CoPC)

Table 3.0: Toxicological Reference Values (TRVs) Recommended for Use In Human Health Risk Assessments for Federal Contaminated sites in Canada

Contaminant of Potential Concern	Non-Carcinogenic| Tolerable Daily Intake(TDI) (mg/kgBW-day)	Carcinogenic | Oral Slope Factor (mg/kgBW-day)-1
Cadmium(Cd)	0.0008	4.2
Mercury(Hg)	0.0003	-

Health Canada

Toxicity Assessment

Cadmium

- Health effects: DNA damage, and cell death.
- It can accumulate in tissues through calcium, iron, zinc, and manganese transporters.
- Adverse health effects at low levels of exposure.

Mercury

- Affects the nervous system, kidneys, and overall health.
- Toxicity depends on its form (inorganic, elemental or organic).
- The International Agency for Research on Cancer (IARC) classifies inorganic mercury as “not classifiable as to its carcinogenicity to humans” (Group 3) due to inadequate human evidence and limited animal evidence (IARC, 1993).

Exposure Assessment and Estimates Equation

Inhalation of Suspended Particulate Matter in Air From Contaminated Soils – with TRV Expressed as an Oral Tolerable Daily Intake (TDI)

If the oral TRV is the only TRV available for the substance (i.e., if there are no data available to derive an inhalation TRV and if the toxicological effects are expected to be similar for ingestion and inhalation exposure routes), the predicted intake of COPCs via inhalation of particulate matter in air is calculated as follows:

$$\text{Dose (mg/kg}_{BW}\text{-day)} = \frac{C_S \times P_{Air} \times IR_A \times RAF_{Inh} \times D_1 \times D_2 \times D_3}{BW}$$

Where:
C_S = concentration of contaminant in soil (mg/kg)
P_{Air} = particulate concentration in air (kg/m^3)
IR_A = receptor air intake (inhalation) rate (m^3/day)
RAF_{Inh} = relative absorption factor by inhalation (unitless)
D_1 = hours per day exposed/24 hours
D_2 = days per week exposed/7 days
D_3 = weeks per year exposed/52 weeks
BW = body weight (kg_{BW})

Box 1: Recommended General Equations for Exposure Dose Estimation – Threshold Effects

General equations are presented below for exposure dose estimation of chemicals associated with a threshold response. Abbreviations denoting variables have been harmonized through all equations.

For non-threshold carcinogenic effects, the reader is referred to HC (2013) guidance on assessment of carcinogens.

Inadvertent Ingestion of Contaminated Soil

The predicted intake of COPCs via ingestion of contaminated soil is calculated as follows:

$$\text{Dose (mg/kg}_{BW}\text{-day)} = \frac{(C_S \times IR_S \times RAF_{Oral} \times D_2 \times D_3)}{BW}$$

Where:
C_S = concentration of contaminant in soil (mg/kg)
IR_S = receptor soil ingestion rate (kg/d)
RAF_{Oral} = relative absorption factor from the gastrointestinal tract (unitless)
D_2 = days per week exposed/7 days
... exposed/52 wee...
...(kg_{BW})

Dermal Absorption from Contaminated Soil

The predicted intake of COPCs via dermal contact with contaminated soil is calculated as follows:

$$\text{Dose (mg/kg}_{BW}\text{-day)} = \frac{[(C_S \times SA_H \times SL_H) + (C_S \times SA_O \times SL_O)] \times nEv \times RAF_{Derm} \times D_2 \times D_3}{BW}$$

Where:
C_S = concentration of contaminant in soil (mg/kg)
SA_H = surface area of hands exposed for soil loading (cm^2)
SL_H = soil loading rate to exposed skin of hands (kg/cm^2-event)
SA_O = surface area exposed other than hands (cm^2)
SL_O = soil loading rate to exposed skin other than hands (kg/cm^2-event)
nEv = number of dermal exposure events/day (assumed to be 1 event/day)
RAF_{Derm} = relative dermal absorption factor (unitless)
D_2 = days per week exposed/7 days
D_3 = weeks per year exposed/52 weeks
BW = body weight (kg_{BW})

Box 3: Hazard quotient (HQ) equations

In the case of oral, dermal, or summed exposures being compared with a tolerable daily intake (TDI) (or similar TRV such as an RfD, etc.) in units of mg/kg_{BW}-day:

$$\text{Hazard Quotient} = \frac{\text{Estimated Dose (mg/kg}_{BW}\text{-d)}}{\text{Tolerable Daily Intake (mg/kg}_{BW}\text{-d)}}$$

Incremental Lifetime Cancer Risk

$$\text{ILCR} = \text{Lifetime Average Daily Dose (µg/kg bw/d)} \times \text{Cancer Slope Factor (µg/kg bw/d)}^{-1}$$

Risk Characterization

- Hazard quotient(HQ) and Incremental Life cancer risk were used in estimating the non-carcinogenic risk and carcinogenic risk
- ILCR values compared with a threshold of 10-5(Federal guideline) and HQ values compared with threshold of 0.2.

CONTAMINANT OF POTENTIAL CONCERN	INCREMENTAL LIFE CANCER RISK(ILCR)	HAZARD QUOTIENT(NON-CANCER)	BELOW OR ABOVE THE THRESHOLD
Mercury	N/A	0.012	Below
Cadmium	0.5*10-5	0.002	Below

Scientific Communication and Stakeholder Engagement

Leverage Multiple Communication Channels

- Workshops with farmers and the Department of Agriculture.
- Used documentary to reach a wider audience.

Engaged Decision Makers

- Involved the Department of Agriculture and Shama District Assembly in the research process from the beginning.
- Provided specific recommendations rather than just problems.

Recommendations

- Long-term monitoring and intervention strategies such as alternative irrigation sources.
- Integrating environmental risk assessment with climate adaptation into the Department of Shama agricultural policy.
- Encouraging the use of PPEs by farmworkers.

Conclusion

The PQRA of Whin Valley Rice Fields found that heavy metal levels were below health risk thresholds. However, continuous monitoring is necessary to detect future contamination risks.

Link
https://www.youtube.com/watch?v=4xzrZPEorZc

Thank you

Questions?