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Ecological and Health Risks Assessment of Potentially Toxic Metals and Metalloids (PTMMs) Contaminants

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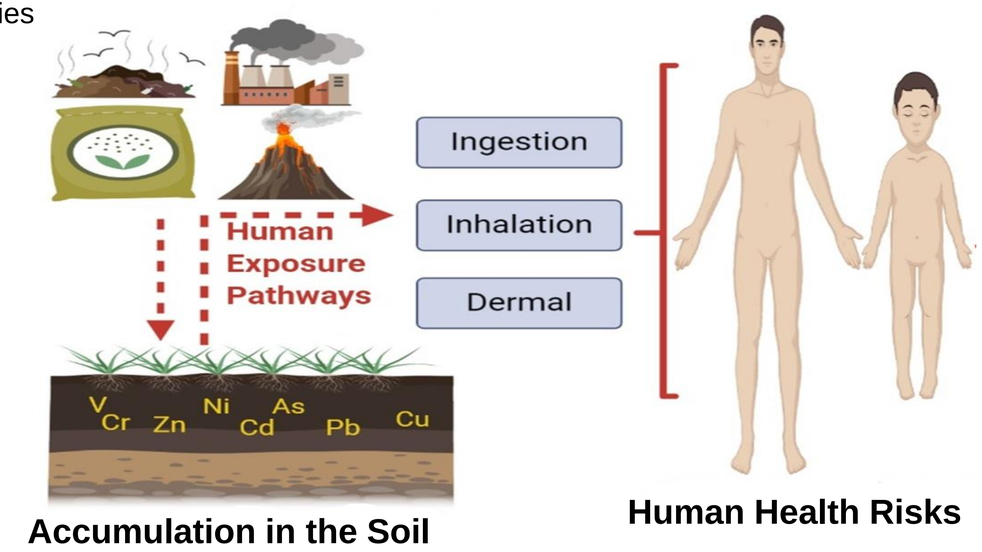
Abstract

- Human activities including agriculture cause PTMMs contamination
- Results showed high cancer risks to humans due to Arsenic (As), Chromium (Cr) and Nickel (Ni) exposure
- Reducing PTMMs bioavailability and innovative remediation technologies are needed
- Future work will investigate As, Cr, and Ni long-term exposure and gastrointestinal bio-accessibilities



Study Background

Previous studies by Usman et al., (2019) and Peng et al., (2016) suggest that soils in some industrial and cultivated areas of Qatar may be contaminated with potentially toxic metals and metalloids including arsenic, chromium, cadmium and nickel

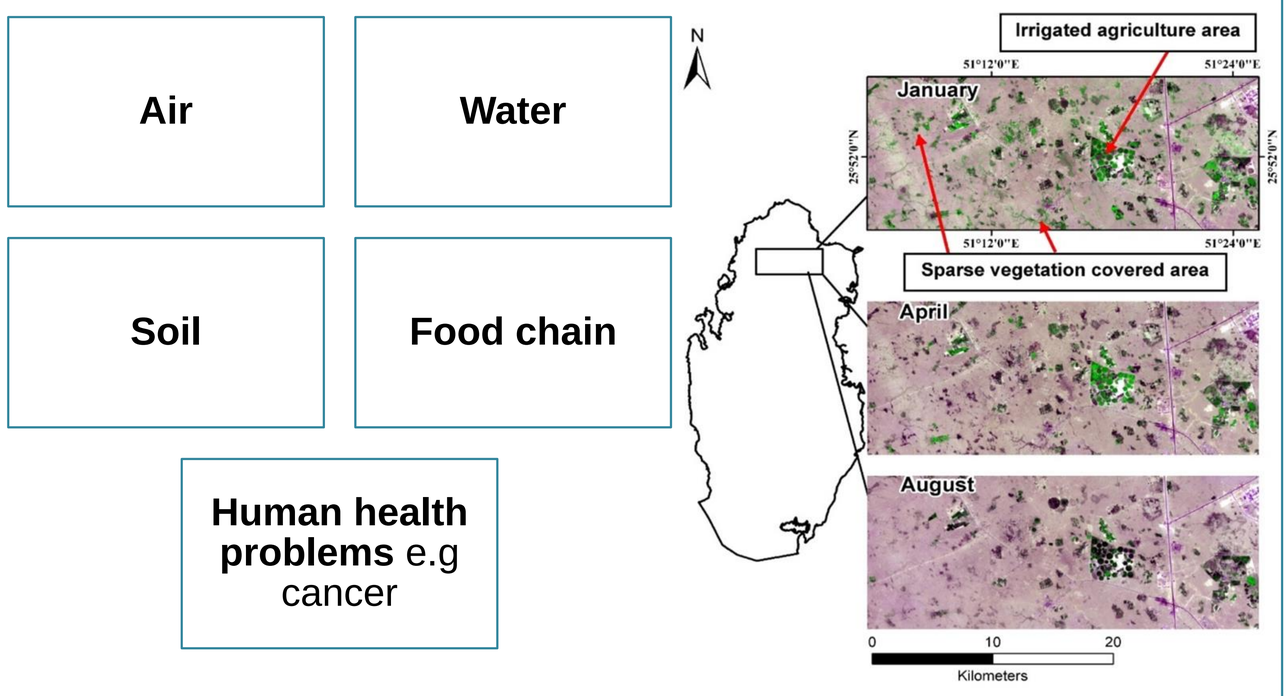
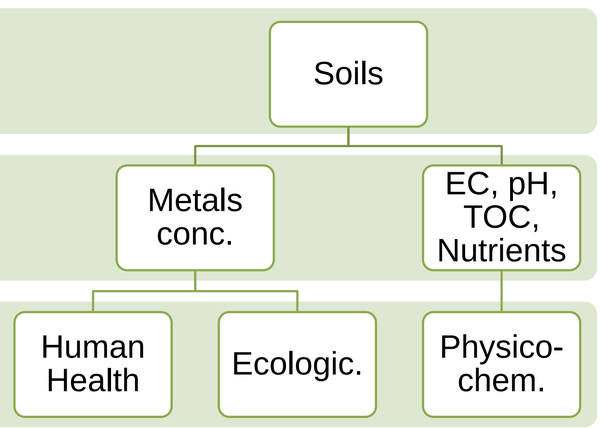


Fig. 1. Potentially toxic metals the environments and synergistic effects on human health

Objectives

1. Analyze the physico-chemical composition of Agricultural soils in Qatar
2. Assess the level of potentially toxic metals and metalloids in the cultivated soils
3. Evaluate the potential ecological and human health risks associated with the metals exposure

Methods Summary



Ecological Risk Evaluation

$$CF_n = \frac{C_{sample}}{C_{background}} \qquad PLI = (CF_1 \times CF_2 \times CF_3 \ldots \times CF_n)^{\frac{1}{n}} \qquad C_f^i = C_b^i / C_r^i$$

$$EF = \frac{(C_x/C_{ref})_{sample}}{(C_x/C_{ref})_{background}} \qquad I_{geo} = \log_2\left(\frac{C_{sample}}{1.5 \times C_{background}}\right) \qquad Er = T_r^i \times C_f^i$$

$$PERI = \sum_{i=1}^{m} Er^i$$

Human Health Risk Evaluation

$$ADD_{ingestion} = \frac{C_{soil} \times IngR \times EF \times ED}{BW_A \times ET_A} \times 10^{-6}$$

$$ADD_{dermal} = \frac{C_{soil} \times ESA_s \times ABS \times AF_s \times EF \times ED}{BW_A \times ET_A} \times 10^{-6}$$

$$ADD_{inhalation} = \frac{C_{soil} \times InhR \times EF \times ED}{BW_A \times ET_A \times EF_p}$$

$$HI = \sum HQ_i = \sum \frac{ADD_i}{RfD_i}$$

$$CR_{inhalation} = \frac{C_{soil} \times InhR \times EF \times ED}{BW_A \times ET_{ca} \times EF_p} \times SF_{inhalation}$$

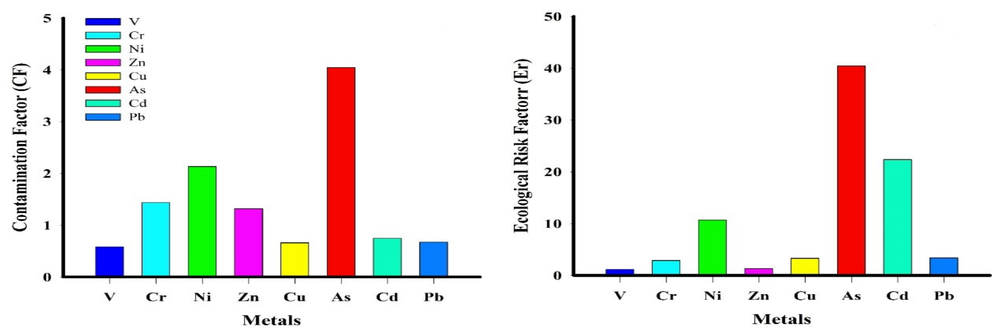
$$CR_{dermal} = \frac{C_{soil} \times ESA_s \times ABS \times AF_s \times EF \times ED}{BW_A \times ET_A} \times 10^{-6} \times SF_{dermal}$$

$$CR_{ingestion} = \frac{C_{soil} \times IngR \times EF \times ED}{BW_A \times ET_{ca}} \times 10^{-6} \times SF_{ingestion}$$

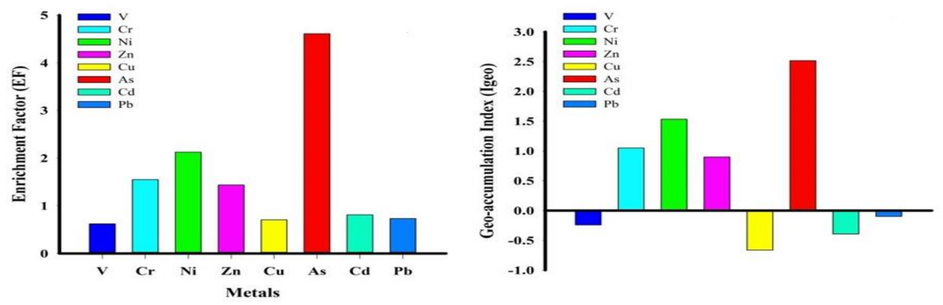
$$TCR = \sum (CR_{ingestion} + CR_{dermal} + CR_{inhalation})$$

Sample Results

- High As, Cr, and Ni contamination (CF > 1) poses ecological risk



- Geo-accumulation index (Igeo) of up to 2.5, and enrichment factor (EF > 1) indicates that up to 58% of the soil is contaminated due to human activities including agriculture



- As, Cr, and Ni, with total carcinogenic risk (TCR = 1.18 × 10−4 and 2.06 × 10−4) indicates cancer risks to humans

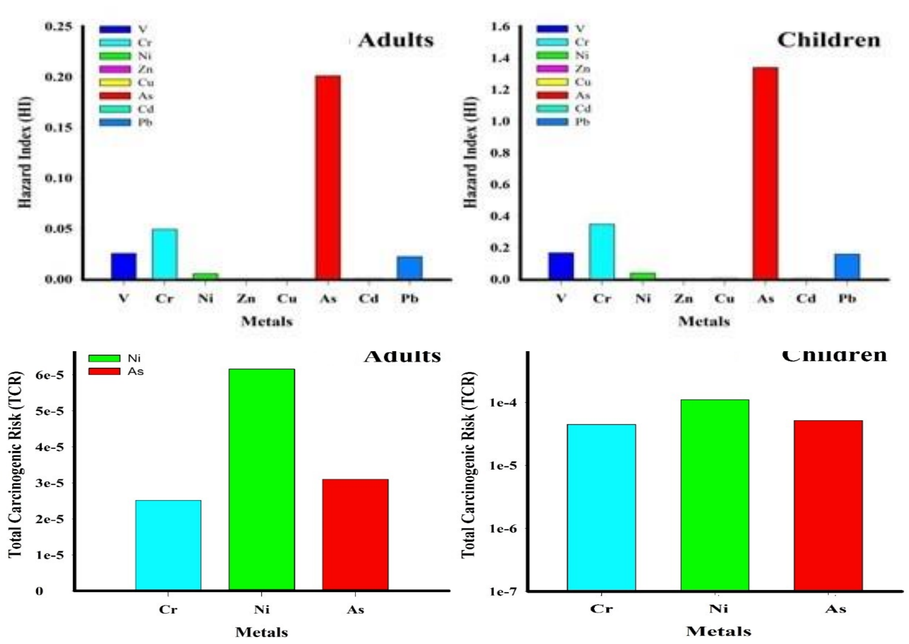


Fig. 2. Summarized results of (A) Contamination/Ecological risk factors (B) Enrichment factor/ Geo-accumulation index (C) Hazard index and (D) Carcinogenic/Total carcinogenic risks

Conclusion/Future Work

1. Arsenic, chromium, and nickel concentrations are significantly higher than USEPA limits in the studied agricultural soils
2. The elements poses ecological and human health (carcinogenic and non-carcinogenic) risks
3. Oral ingestion is the principal exposure pathway in both adults and children
4. Children are the most vulnerable to the elements toxic effects, and likely to develop cancer over due to As and Ni exposure
5. Further studies on As, Cr, and Ni gastrointestinal bio-accessibilities are needed to fully understand the long-term exposure effects and the cancer-causing potential of these elements over a lifetime

Selected References

1. Peng, Y. et al., (2016). Digital mapping of toxic metals in Qatari soils using remote sensing and ancillary data. *Remote Sensing*, 8, 1003.
2. Risk assessment guidance for superfund; Office of Emergency and Remedial Response, US Environmental Protection Agency: 1989; Vol. 1.

Acknowledgement

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