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# Natural and depleted uranium in the topsoil of Qatar: Is it something to worry about?

Basem Shomar [a,*], Mohamed Amr [b], Khalid Al-Saad [b], Yasir Mohieldeen [a]

[a] Qatar Environment and Energy Research Institute (QEERI), Qatar Foundation, P.O. Box 5825, Doha, Qatar
[b] Central Laboratory Unit, Qatar University, P.O. Box 2713, Doha, Qatar

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ABSTRACT

This study examines uranium in soils of Qatar to investigate whether there is any detectable traces of depleted uranium (DU). 409 soil samples were collected using a 10 km grid system throughout the State of Qatar. The U concentrations and isotopic compositions ($^{235}U/^{238}U$) were determined using an ICP-MS. The U concentrations range from 0.05 to 4.7 mg/kg and the $^{235}U/^{238}U$ isotopic signatures are in the range 0.007–0.008, i.e. comparable to the isotopic ratio in natural uranium (NU). The distribution of these concentrations in the topsoil were used to see correlations with locations of pollution point sources and environmentally hot areas associated with human activity: industrial estates, solid waste dumping sites, wastewater treatment plants, sea harbors, airports, and public transport network. New thematic maps were built using Geographic Information System (GIS) software. The results showed that there is no linkage between the occurrence, distribution, concentrations and isotopic ratios of U and these hotspots. More importantly, due to the low concentration of organic matter (OM) in soils of Qatar, very limited P-fertilization, the alkaline nature of soil (pH 8) and low Fe/Mn contents make soil uranium concentrations very low. The residential areas, including the capital Doha, had the lowest total concentrations of uranium and isotopic ratios of the country while the northern and western parts showed the highest values.



## 1. Introduction

Uranium (U) is a naturally occurring element found in low levels within rock, soil, and water (UNSCEAR, 1993). U concentrations in soil naturally range between 300 μg/kg and 11.7 mg/kg (Kabata-Pendias and Pendias, 2000). The occurrence, source, distribution, concentration, mobility, and the speciation of uranium in the soil environment depend on both natural and anthropogenic factors. Naturally, U is released into solution by weathering of primary minerals; therefore uranium occurrence varies with climate and underlying bedrock conditions (Gueniot et al., 1988).

In soils, uranium mobility is influenced by soil type and physico-chemical properties (Echevarria et al., 2001). Several uranium minerals in soil of arid areas could be formed by weathering, diagenetically during soil formation or sedimentation processes (Ilani and Strull, 1989) where NU concentration ranged between 200 and 3900 mg/kg. Two distinct types of uranium mineralization may occur in arid soils: primary and secondary types. Primary uranium mineralization is represented by uranium enrichments in phosphorites of sedimentary phosphate deposits age as well as by uranium anomalies associated with epigenetic iron-oxide veins. Secondary uranium mineralization of Quaternary age is formed by weathering and soil formation processes under arid conditions. The secondary uranium minerals are associated with gypsum rich crusts and veins in the soils (Ilani and Strull, 1989). Minerals of U (e.g. meta-autunite, meta-tyuyamunite and carnotite) are associated with ions of vanadate, phosphate and carbonate. Secondary uranium minerals are associated with gypsum which forms thin veins and is found also as a matrix in pedogenic layers that range from 0.2 to 1.5 m in thickness (Ilani and Strull, 1989).

Echevarria et al. (2001) measured the uranium sorption ratios and found that they are affected by soil type and chemical composition. Additionally, soil pH is highly linearly correlated with the logarithm of uranium sorption ratios. At the same time, U sorption behavior depends on the occurrence of uranium oxide and carbonate complexes. The study by Gueniot et al. (1988) indicated that soils rich in iron and aluminum but still conserving a substantial amount of silica showed the largest U accumulation, while soils with only iron and aluminum oxides remaining, and minor kaolinite, showed significant depletion of U. A strong association between Fe-oxides and soil uranium has been found (Pett-Ridge et al., 2007). Moreover, the study found that soil U contents increase between 20-fold and 60-fold with age along the chronosequence.

Depleted uranium (DU) has been used extensively during weapons testing and recent military conflicts (Handley-Sidhu et al.,

* Corresponding author. Tel.: +974 4454 2872; fax: +974 4454 1528.
*E-mail address:* bshomar@qf.org.qa (B. Shomar).

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2010). The firing of weapons containing depleted uranium (DU) during conflicts and military testing has resulted in the deposition of DU in a variety of sand-rich environments (Handley-Sidhu et al., 2009). The 1991 Gulf War alone resulted in the deposition of 321 tons of DU into the desert regions of Kuwait and Iraq (Handley-Sidhu et al., 2009). Test firing of DU-containing weapons at military ranges have also deposited DU in sand-rich environments, such as the Yuma Proving Ground, USA desert environment (Johnson et al., 2004), dune sands of the Eskmeals range, UK (ca. 15 tons) (Toque and Baker, 2006) and terrestrial and marine sediments of the Aberdeen Proving Ground, USA (>70 tons of DU) (Dong et al., 2006).

Uranium is classified as "very toxic" (Health and Safety Executive, 1995), causing skin, lung, intestinal and bone marrow disorders, particularly where individuals have been chronically exposed by skin contact, direct ingestion or inhalation of dust (such as in mines and processing). U is taken-up by plants but most U ingested from food and water is excreted and does not remain in the body (Taylor, 1997). All three main isotopes of U ($^{235}$U, $^{236}$U, $^{238}$U) are radioactive alpha emitters with long half-lives (Jones et al., 1990). Naturally occurring uranium is composed of three major isotopes, uranium-238 (99.2739–99.2752% natural abundance), uranium-235 (0.7198–0.7202%), and uranium-234 (0.0050–0.0059%) (Wikipedia, 2013).

For the general population, chemical toxicity by inhalation of dust or direct ingestion is considered a greater hazard than radioactive toxicity (Menzel, 1968). Although less radioactive, DU has the same chemotoxicity as natural uranium and poses a threat to an exposed human populations (Bleise et al., 2003; Choy et al., 2006).

Iraq, a near neighbor to Qatar, has received extensive (400 tonnes) DU contamination from the two wars in 1991 and 2003, and the predicted cost for remediating the 300 sites is about US$ 30 Million (Dutch Peace Group, 2013). In the State of Qatar, no analysis of NU and DU contents of topsoils currently exist, therefore the objectives of this study were to (1) determine the occurrence and distribution of natural and depleted uranium in the topsoil of Qatar; (2) use GIS to assess the impacts of current land use and envi-

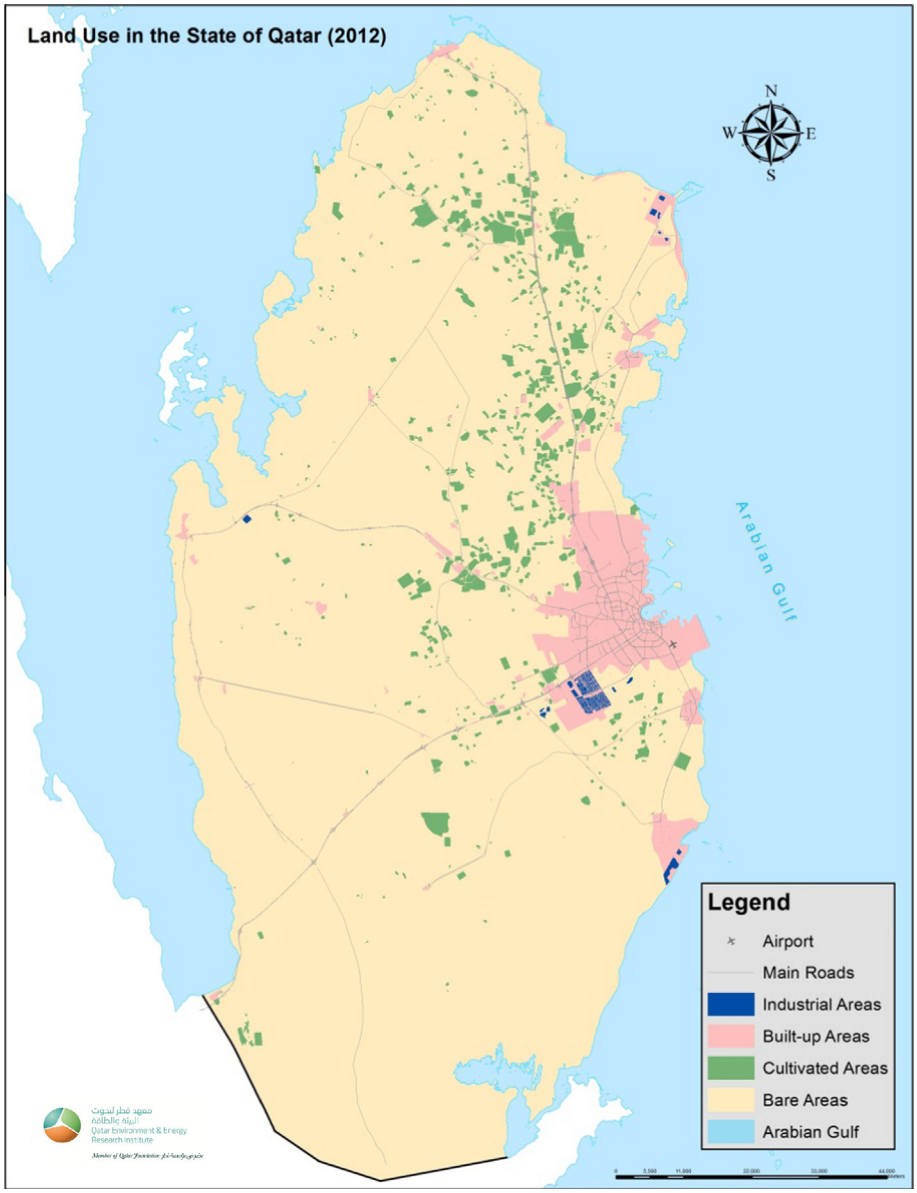


**Fig. 1.** Base map of Qatar showing the land use.