The vanishing Aral Sea: health consequences of an environmental disaster

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Access to safe water and food is linked to global, regional and local climate changes. In some areas swift changes have entailed serious health-related consequences. An alarming example is found in the Aral Sea area of Central Asia.
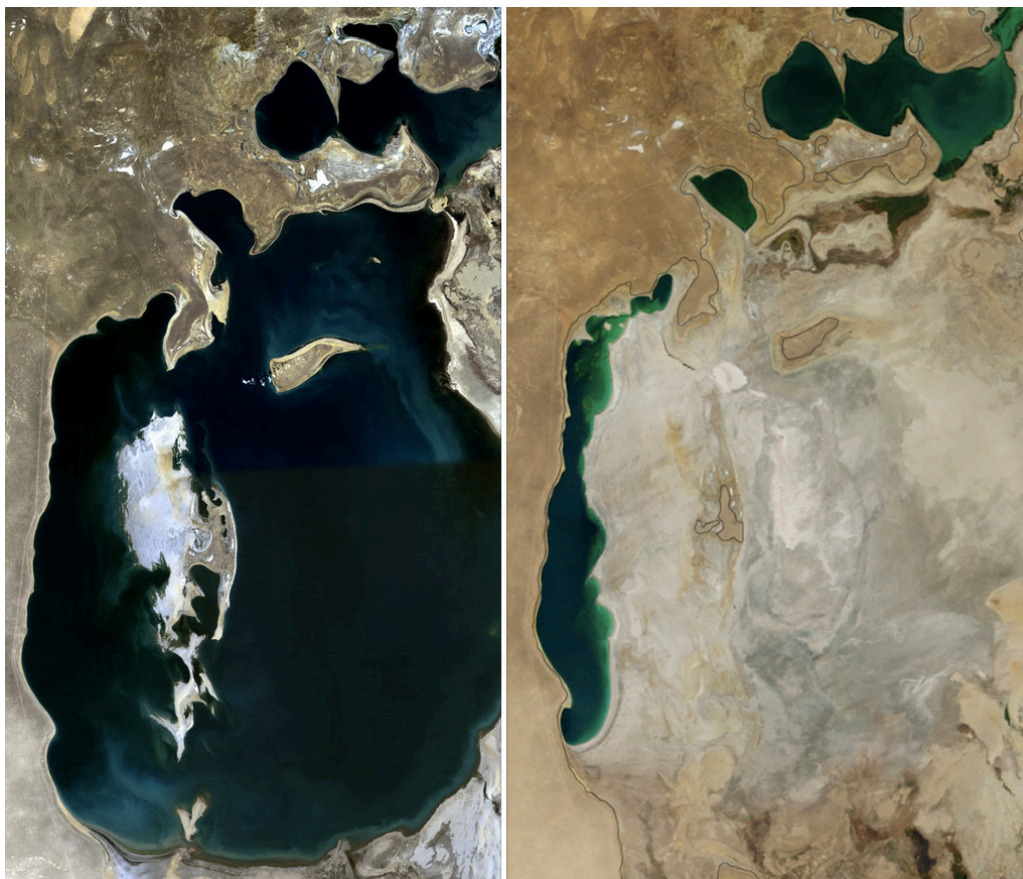
A comparison of the Aral Sea in 1989 (left) and 2014 (right). Photo: NASA

The Aral Sea area, located on the border between Kazakhstan and Uzbekistan, was once the fourth largest inland sea in the world. Since the 1960s, water volume has been reduced by a factor of fourteen (1). Tributary water to the Aral Sea derives from the rivers Amu Darya originating in Tajikistan, and Syr Darya originating in Kyrgyzstan. Early in the 20th century demand for river water to supply local agriculture, primarily the cotton industry, led to construction of irrigation systems (2). A highly inefficient system for water allocation combined with excessive resource exploration was the result. Subsequent failure to maintain infrastructure, in tandem with large emissions of pollutants have had serious consequences for people inhabiting the areas around the Aral Sea.

After the Soviet Union created collective farms in 1929, water usage increased and the Aral Sea started shrinking. By 1987, the lake had split into two separate parts (3). Water distribution was complicated by the collapse of the Soviet Union in 1991, creating several new countries with separate water policies (4). Uzbekistan is today one of the world's largest cotton producers and needs large amounts of water to sustain production (5). A simultaneous population increase complicates the severe water shortage in the area (6) and contributes to the environmental disaster, evident by the disappearance of the Aral Sea. Its role as an important food source is impaired due to increased salinity. In 1983 more than 20 different fish species were declared extinct (7). River deltas have been replaced by desert, mediating a replacement of the original flora with hardier plants (3). Local climate change has occurred simultaneously with the disappearance of water. Formerly hot, humid regions are acquiring a cold, dry desert climate (8).

Pollution

No rivers flow out of the Aral Sea; water disappears through evaporation. Before construction of the excessive irrigation systems, water level was kept stable by inflow from Amu Darya and Syr Darya. As human use of river water has increased, the composition of lake water has changed. Salt concentration has increased tenfold [9] and local groundwater has a salt concentration reaching 6 g/L. This is six times higher than the concentration considered safe by WHO. Naturally, local inhabitants are exposed to saline water [7] and in 2000 only 32 % had access to safe drinking water [10]. An increased frequency of storms carries 43 million tons of dust and sand from the dried-out sea floor through the air yearly [11, 12]. Accordingly, the rate of dust deposition is among the highest in the world [12] and contains large amounts of salts and pesticides, probably related to the water quality in the tributary rivers. Fertilisers, chlorinated organic pesticides and other chemicals are used in large quantities for agricultural purposes and pollutant-rich water returns to the rivers that supply the Aral Sea [13]. Pollution also originates from the extensive mining industry in the area. Drain water contains heavy metals which flow into the rivers [14]. In Amu Darya, concentrations of copper, nickel and lead all exceed WHO recommendations [14].

Aral Sea concentrations of the pesticides dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyltrichloroethane (DDT) do not exceed WHO recommendations [15]. It is, however, apparent that both water [14] and soil [12] in the region are affected by toxic pollutants from industry and agriculture. The concentration of dioxin and dioxin-like compounds (polychlorinated biphenyl (PCB), polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)) has been found in fish, sheep, milk, eggs and several other foods. Carrots and onions, important in the local diet, have been shown to contain high amounts of chlorinated organic pesticides. High levels of hexachlorocyclohexane (HCH) have been found in most samples [16].

Human samples reflect the high amount of pollutants in water and food.

DDE blood levels, for example, are higher than in Russian Arctic settlements [17]. A lifelong exposure is evident. Blood samples from pregnant women and umbilical cords show high amounts of DDE, also found in breast milk [18]. DDT levels in breast milk from Aralsk have been proven to be higher than in the rest of Kazakhstan [19]. Although plasma concentrations of perfluoroalkyl substances (PFASs), which are used in products for their fat and water-resistant abilities, have been shown to be lower than in Arctic Russia [20], school-aged children in Aralsk have high blood levels of DDE and DDT compared to other parts of Kazakhstan and two European countries [21, 22].

Health-related consequences

Living in the Aral Sea area has detrimental consequences for fertility, both in people growing up in the area and for adult immigrants (23, 24). Furthermore, in the late 1990s infant mortality was between 60 – 110/1000, a figure far higher than in Uzbekistan (48/1000) and Russia (24/1000) (25). At the same time, body mass index (BMI) was inversely correlated with blood concentration of PCBs, DDTs and DDEs in children between 7 and 17 years, advocated as an effect of malabsorption. Values of insulin-like growth factor type 1 (IGF-1) tended to correlate with a reduction in body mass index (26). It is known that low IGF-1 values may be associated with high concentrations of DDT or DDT metabolites in the body (27).

In the late 1990s, Kazakh children believed to be harmed by Aral Sea pollution were sent to a rehabilitation centre in Almaty. Clinical findings included skin lesions, heart and kidney disease. Growth retardation and late sexual maturation were common (28). Further, anaemia was related to settlement near the lake (29) and local children had impaired renal tubular function. Chronic heavy-metal exposure has been shown to cause such damage, and polluted water could be causative (30). Hypercalciuria in children (31) could possibly be related to intake of saline-rich water, food and dust, or renal tubular dysfunction, associated with toxic damage after exposure to substances such as lead and cadmium (29).

Studies conducted in 2000 examined the respiratory function of local children. In an area within 200 kilometres of the Aral Sea, schoolchildren had low vital capacity and a high cough rate (32). Surprisingly, dust exposure appeared unrelated to the prevalence of asthma (33). Therefore, it is still uncertain whether the environmental disaster has had a direct impact on the frequency of respiratory disease (29).

Compared with far eastern Kazakhstan, the Aral Sea population seems more prone to develop cancer (34, 35). During the 1980s, the occurrence of liver cancer doubled (36), while the incidence of oesophageal, lung and stomach cancer appear highest (37). Inhabitants of the Uzbek part of the Aral Sea area subjectively experience their own health as poor, correlating with concerns about the environmental disaster. A large percentage of residents wish to emigrate (25, 38).

Water access

With the disappearance of rivers flowing into the Aral Sea area, drinking water is a highly valuable resource. Water shortage and contamination of stored drinking water are important causes of faecal-oral transmission of disease in Aral Sea area households (39). Accordingly, hepatitis A (11) and diarrhoeal disease are frequently reported. At the turn of the century, the infant death rate due to diarrhoea was twice that of bordering areas (10). Parasitic infections and tuberculosis are also a challenge (28). Some claim that the high incidence of disease, including tuberculosis, is related to increased poverty, resulting in poorer personal hygiene and malnutrition (40). Indeed, multi-drug resistant tuberculosis presents a significant challenge in this region (29, 41).

Inadequate sanitation and water access represent a considerable risk for diarrhoeal disease, one of the main global contributors to child mortality, causing one in ten child deaths (42). In total more than 600 million people lack improved drinking water (43). Although access to safe water is increasing, environmental disasters such as those affecting the Aral Sea, and unexpected effects of climate change might impede this development. In May 2007, a massive bloom of the toxin-producing cyanobacteria *Microcystis* occurred in China's third largest freshwater lake, Taihu. This crisis, attributed to an unusually warm spring, left approximately two million people without drinking water for a week (44). More predictable effects of climate change will also affect freshwater access. Models predicting global warming show that it will occur more rapidly at high altitudes (45), thus affecting communities relying on mountain glaciers for their water supply. Big cities such as Quito and La Paz in South America partly depend on water from glaciers, some of which are rapidly retreating (45). The Aral Sea area is also at risk. Both Amu Darya and Syr Darya are provided with glacial water from the Pamir and Tian Shan Mountains, respectively. The melting glaciers and Arctic ice-cap (46) entail equally disturbing challenges for small island nations, such as Kiribati, that risk being flooded (47).

An alarming signal

As we have seen, global, regional and local climate change can have negative consequences for human health. The Aral Sea disaster shows the result of short-sighted human exploitation of nature and is an alarming signal, indicating that all human activities with potential climate effects must be carefully thought through.

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