Tidsskriftet Tidsskrift for Den norske legeforening

The vanishing Aral Sea: health consequences of an environmental disaster

GLOBAL HELSE

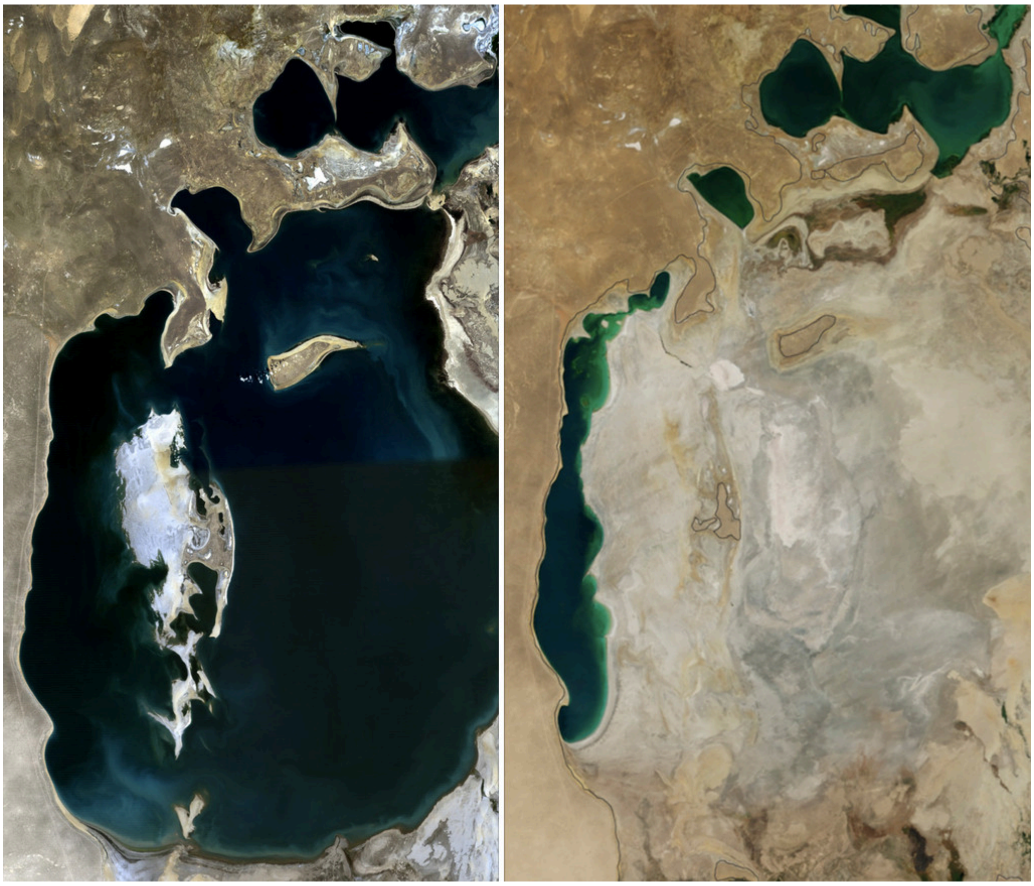
TURID AUSTIN WÆHLER

Turid Austin Wæhler (born 1985), works at the Centre for Arctic and Global Health at the University of Tromsø – The Arctic University of Norway. She holds an MSc in Peace and Conflict Studies with a focus on water conflicts in Central Asia from the University of Tromsø and an MSc in Russian and Eastern European Studies from the University of Glasgow.
The author has completed the ICMJE form and reports no conflicts of interest.

ERIK SVEBERG DIETRICHS

E-mail: erik.sveberg.dietrichs@uit.no
Erik Sveberg Dietrichs (born 1985), resident doctor at the Department of Clinical Pharmacology, at the University Hospital of North Norway. He holds a postdoc position in the Anaesthesia and Critical Care Research Group at the University of Tromsø – The Arctic University of Norway and the Norwegian Air Ambulance Foundation. He defended his doctoral thesis at the University of Tromsø in 2015.
The author has completed the ICMJE form and reports no conflicts of interest.

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.

This article is part of the series 'Global Health in the Era of Agenda 2030', a collaboration between Norad, the Centre for Global Health at the University of Oslo and The Journal of the Norwegian Medical Association. Articles are published in English only. The views and opinions expressed in the articles are those of the authors only.

LITERATURE

1. Gaybullaev B, Chen S-C, Gaybullaev D. Changes in water volume of the Aral Sea after 1960. Appl Water Sci 2012; 2: 285 - 91. [CrossRef]

2. Weinthal E. State Making and Environmental Cooperation. Cambridge, MA: The MIT Press, 2002.

3. Micklin PP. Managing Water in Central Asia. Washington, DC: Chatam House, 2000.

4. Wæhler TA. Trouble between neighbours: the Rogun Dam project in Tajikistan. Nordisk Ost Forum 2012; 26: 245 - 62.

5. MacDonald S. Economic Policy and Cotton in Uzbekistan. Washington, DC: United States Department of Agriculture 2012.

6. Froebrich J, Bauer M, Ikramova M et al. Water quantity and quality dynamics of the THC–Tuyamuyun Hydroengineering Complex–and implications for reservoir operation. Environ Sci Pollut Res Int 2007; 14: 435 - 42. [PubMed][CrossRef]

7. Small I, van der Meer J, Upshur RE. Acting on an environmental health disaster: the case of the Aral Sea. Environ Health Perspect 2001; 109: 547 - 9. [PubMed][CrossRef]

8. Small EE, Sloan LC, Nychka D. Changes in Surface Air Temperature Caused by Desiccation of the Aral Sea. J Clim 2001; 14: 284 - 99. [CrossRef]

9. Micklin P. The Aral Sea Disaster. Annu Rev Earth Planet Sci 2007; 35: 47 - 72. [CrossRef]

10. Ferriman A. Charity calls for help for people of Aral sea area. BMJ 2000; 320: 734. [PubMed][CrossRef]

11. Small I, Falzon D, van der Meer JBW et al. Safe water for the Aral Sea Area: could it get any worse? Eur J Public Health 2003; 13: 87 - 9. [PubMed][CrossRef]

12. O'Hara SL, Wiggs GF, Mamedov B et al. Exposure to airborne dust contaminated with pesticide in the Aral Sea region. Lancet 2000; 355: 627 - 8. [PubMed][CrossRef]

13. Crosa G, Stefani F, Bianchi C et al. Water security in Uzbekistan: implication of return waters on the Amu Darya water quality. Environ Sci Pollut Res Int 2006; 13: 37 - 42. [PubMed][CrossRef]

14. Törnqvist R, Jarsjö J, Karimov B. Health risks from large-scale water pollution: trends in Central Asia. Environ Int 2011; 37: 435 - 42. [PubMed][CrossRef]

15. Bosch K, Erdinger L, Ingel F et al. Evaluation of the toxicological properties of ground- and surface-water samples from the Aral Sea Basin. Sci Total Environ 2007; 374: 43 - 50. [PubMed][CrossRef]

16. Muntean N, Jermini M, Small I et al. Assessment of dietary exposure to some persistent organic pollutants in the Republic of Karakalpakstan of Uzbekistan. Environ Health Perspect 2003; 111: 1306 - 11. [PubMed][CrossRef]

17. Sandanger TM, Anda EE, Dudarev AA et al. Combining data sets of organochlorines (OCs) in human plasma for the Russian Arctic. Sci Total Environ 2009; 407: 5216 - 22. [PubMed][CrossRef]

18. Ataniyazova OA, Baumann RA, Liem AK et al. Levels of certain metals, organochlorine pesticides and dioxins in cord blood, maternal blood, human milk and some commonly used nutrients in the surroundings of the Aral Sea

(Karakalpakstan, Republic of Uzbekistan). Acta Paediatr 2001; 90: 801 - 8. [PubMed][CrossRef]

19. Hooper K, Petreas MX, Chuvakova T et al. Analysis of breast milk to assess exposure to chlorinated contaminants in Kazakstan: high levels of 2,3,7, 8-tetrachlorodibenzo-p-dioxin (TCDD) in agricultural villages of southern Kazakstan. Environ Health Perspect 1998; 106: 797 - 806. [PubMed]

20. Hanssen L, Dudarev AA, Huber S et al. Partition of perfluoroalkyl substances (PFASs) in whole blood and plasma, assessed in maternal and umbilical cord samples from inhabitants of arctic Russia and Uzbekistan. Sci Total Environ 2013; 447: 430 - 7. [PubMed][CrossRef]

21. Erdinger L, Eckl P, Ingel F et al. The Aral Sea disaster–human biomonitoring of Hg, As, HCB, DDE, and PCBs in children living in Aralsk- and Akchi, Kazakhstan. Int J Hyg Environ Health 2004; 207: 541 - 7. [PubMed][CrossRef]

22. Jensen S, Mazhitova Z, Zetterström R. Environmental pollution and child health in the Aral Sea region in Kazakhstan. Sci Total Environ 1997; 206: 187 - 93. [PubMed][CrossRef]

23. Kultanov BZ, Dosmagambetova RS, Ivasenko SA et al. The Study of Cellular and Molecular Physiological Characteristics of Sperm in Men Living in the Aral Sea Region. Open Access Maced J Med Sci 2016; 4: 5 - 8. [PubMed][CrossRef]

24. Turdybekova YG, Dosmagambetova RS, Zhanabayeva SU et al. The Health Status of the Reproductive System in Women Living In the Aral Sea Region. Open Access Maced J Med Sci 2015; 3: 474 - 7. [PubMed][CrossRef]

25. Crighton EJ, Elliott SJ, Upshur R et al. The Aral Sea disaster and self-rated health. Health Place 2003; 9: 73 - 82. [PubMed][CrossRef]

26. Mazhitova Z, Jensen S, Ritzén M et al. Chlorinated contaminants, growth and thyroid function in schoolchildren from the Aral Sea region in Kazakhstan. Acta Paediatr 1998; 87: 991 - 5. [PubMed][CrossRef]

27. Boada LD, Lara PC, Alvarez-León EE et al. Serum levels of insulin-like growth factor-I in relation to organochlorine pesticides exposure. Growth Horm IGF Res 2007; 17: 506 - 11. [PubMed][CrossRef]

28. Zetterström R. Child health and environmental pollution in the Aral Sea region in Kazakhstan. Acta Paediatr Suppl 1999; 88: 49 - 54. [PubMed][CrossRef]

29. Crighton EJ, Barwin L, Small I et al. What have we learned? A review of the literature on children's health and the environment in the Aral Sea area. Int J Public Health 2011; 56: 125 - 38. [PubMed][CrossRef]

30. Kaneko K, Chiba M, Hashizume M et al. Renal tubular dysfunction in children living in the Aral Sea Region. Arch Dis Child 2003; 88: 966 - 8. [PubMed][CrossRef]

31. Kaneko K, Chiba M, Hashizume M et al. Extremely high prevalence of hypercalciuria in children living in the Aral Sea region. Acta Paediatr 2002; 91: 1116 - 20. [PubMed][CrossRef]

32. Kunii O, Hashizume M, Chiba M et al. Respiratory symptoms and pulmonary function among school-age children in the Aral Sea region. Arch Environ Health 2003; 58: 676 - 82. [PubMed][CrossRef]

33. Bennion P, Hubbard R, O'Hara S et al. The impact of airborne dust on respiratory health in children living in the Aral Sea region. Int J Epidemiol 2007; 36: 1103 - 10. [PubMed][CrossRef]

34. Mamyrbayev A, Dyussembayeva N, Ibrayeva L et al. Features of Malignancy Prevalence among Children in the Aral Sea Region. Asian Pac J Cancer Prev 2016; 17: 5217 - 21. [PubMed]

35. Mamyrbayev A, Djarkenov T, Dosbayev A et al. The Incidence of Malignant Tumors in Environmentally Disadvantaged Regions of Kazakhstan. Asian Pac J Cancer Prev 2016; 17: 5203 - 9. [PubMed]

36. Kist AA, Zhuk LI, Danilova EA et al. Mapping of ecologically unfavorable territories based on human hair composition. Biol Trace Elem Res 1998; 64: 1 - 12. [PubMed][CrossRef]

37. Igissinov N, Tereshkevich D, Moore MA et al. Age characteristics of incidences of prevalent cancers in the Aral Sea area of Kazakhstan. Asian Pac J Cancer Prev 2011; 12: 2295 - 7. [PubMed]

38. Crighton EJ, Elliott SJ, Meer J et al. Impacts of an environmental disaster on psychosocial health and well-being in Karakalpakstan. Soc Sci Med 2003; 56: 551 - 67. [PubMed][CrossRef]

39. Herbst S, Fayzieva D, Kistemann T. Risk factor analysis of diarrhoeal diseases in the Aral Sea area (Khorezm, Uzbekistan). Int J Environ Health Res 2008; 18: 305 - 21. [PubMed][CrossRef]

40. Ataniyazova O, Adrian S, Mazhitova Z et al. Continuing progressive deterioration of the environment in the Aral Sea Region: disastrous effects on mother and child health. Acta Paediatr 2001; 90: 589 - 91. [PubMed][CrossRef]

41. Shen MJ, Zipes DP. Role of the autonomic nervous system in modulating cardiac arrhythmias. Circ Res 2014; 114: 1004 - 21. [PubMed][CrossRef]

42. Wolf J, Prüss-Ustün A, Cumming O et al. Assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: systematic review and meta-regression. Trop Med Int Health 2014; 19: 928 - 42. [PubMed][CrossRef]

43. WHO. Progress on Sanitation and Drinking Water, 2015. http://apps.who.int/iris/bitstream/10665/177752/1/9789241509145_eng.pdf?ua=1 (4.9.2017)

44. Qin B, Zhu G, Gao G et al. A drinking water crisis in Lake Taihu, China: linkage to climatic variability and lake management. Environ Manage 2010; 45: 105 - 12. [PubMed][CrossRef]

45. Bradley RS, Vuille M, Diaz HF et al. Climate change. Threats to water supplies in the tropical Andes. Science 2006; 312: 1755 - 6. [PubMed][CrossRef]

46. National Snow & Ice Data Center. 2017 ushers in record low extent. http://nsidc.org/arcticseaicenews/2017/02/2017-ushers-in-record-low-extent/ (01.06.2017)

47. McIver L, Woodward A, Davies S et al. Assessment of the health impacts of climate change in Kiribati. Int J Environ Res Public Health 2014; 11: 5224 - 40. [PubMed][CrossRef]

Publisert: 2 October 2017. Tidsskr Nor Legeforen. DOI: 10.4045/tidsskr.17.0597
Received 5.7.2017, first revision submitted 14.8.2017, accepted 4.9.2017.