The Aral Sea environmental health crisis

Phillip Whish-Wilson

Introduction

The Aral Sea was once the fourth largest inland body of water on earth with a surface area of 66,000 km^2. In 1960, the mean water level was 53.4 m and it contained 1090 km^3 of water (Glantz 1999). The destruction of the sea and its ecosystems constitutes one of the greatest man-made environmental disasters in history. The ecological catastrophe has been associated with a sharp decline in the health status of the human population in the region. The environmental deterioration is expected to continue and the health outlook is similarly grim. There is a requirement for immediate health related assistance from the international community.

Background

Central Asia is landscaped by desert, semi-desert, dry steppes and high mountains. The Aral Sea is sandwiched between two deserts, the Karakum and the Kyzylkum. In the Aral Sea region, summer temperatures reach 40^0C and winter temperatures fall to -20^0C. Precipitation is minimal. The main volume of water comes from high glaciers feeding into the two main rivers, the Syr Darya and the Amu Darya, which enter the sea from the north and south respectively. Historically, the Amu Darya supplied about 70% of the Aral Sea's water.

In ancient times the Aral Sea region was an oasis, where thousands of people prospered as fishermen, farmers, merchants, hunters and craftsmen. It was once an important area that connected Europe and Asia as part of the Great Silk Road. Irrigation farming was being undertaken thousands of years ago (Glantz 1999).

There were over 1100 islands in the Aral Sea, with countless lagoons and shallow straits. Aral is the Kazak word for island. The vast river deltas played a vital role in fish breeding. A flourishing fishing industry exploited over twenty commercially valuable species. A busy shipping trade connected the northern port of Aralsk to the river ports of the Amu Darya, some as far distant as Tajikstan (Okda 2001).

The Aral Sea is bordered by Kazakhstan to the north and Uzbekistan to the south. The Aral Sea Basin includes Uzbekistan, Tajikstan, and parts of Kazakstan, Kyrgystan, and Turkmenistan. Around the southern edge of the Aral Sea is the Karakalpakstan Republic, an autonomous republic incorporated into Uzbekistan. The people of Karakalpakstan, population approximately 1.5 million, are culturally and ethnically distinct from the rest of Uzbekistan and have borne much of the brunt of the ecological disaster.

The Desiccation of the Aral Sea

Soon after the creation of the Soviet Union, its leaders made plans to increase the production of cotton (often referred to as white gold) in Central Asia by expanding irrigation. Stalin's five-year plans demanded that the Soviet Union become self sufficient in cotton and that increasing quotas and targets be met. This led to massive irrigation projects in the Aral Sea Basin commencing in the 1950s, accompanied by large-scale monocropping of cotton and reclamation of land from other agricultural pursuits. Kruschev continued the demand for increased cotton production and added the goal of Soviet self-sufficiency in rice, further ramping up the demand for irrigation water (Glantz 1999).

The scale of the irrigation projects was enormous and little heed was paid to downstream requirements. Irrigation techniques were inefficient with open waterways causing much waste. Little regard was given to the need for proper drainage. The largest of the canals, the Karakam Canal, now diverts about 23-30% of the Amu Darya's total flow, about 15-20 km^3, to Turkmenistan (Glantz 1999).

In the past, approximately half of the flow of the two major rivers reached the Aral Sea. The drying of the Aral Sea became visible in the 1960s. By the 1980s, during dry or average years no river water reached the sea at all. There was an average decline in water level during the 1960s of 0.21 m/year, in the 1970s of 0.6 m/year, and in the 1980s of 0.8 m/year. It has now lost 80 % of its volume and exposed 3.6 mil hectares of seabed (Stone 2001). Its surface level has shrunk by half, the level fallen by 19 m and in some sites the sea's edge is over 100 km from its former shore (Hinrichsen 2000).

To increase cotton yields, large quantities of pesticides were used, including the organochlorines dichlorodiphenyl-trichloroethans (DDTs), hexachloro-cyclohexane compounds (HCH, Lindane), and Toxaphene. While DDT was banned in the 1970s there is evidence that its use persisted in the Aral Sea Basin (Jensen et al. 1997). Toxophene was banned in the west due to its carcinogenic and mutagenic effects. It is unknown if it is still used in Central Asia, but it has been largely replaced by Lindane. As excessive irrigation practices continued salinity of soils and water increased. To improve crop yields, more water, fertiliser, and pesticides were applied.

The exposed former seabed consists of lifeless, salt encrusted sands contaminated by pesticides. Large dust storms, which can occur ten times annually, scour the seabed and transport tens of millions of tons of dust per year to be dumped on the surrounding land and its inhabitants (Glantz 1999; Hinrichsen 2000; Stone 2001). Because of the prevailing northerly winds, Karakalpakstan is particularly affected. One study in Turkmenistan, to the south of Karakalpakstan, showed high rates of particulate matter deposition, with an average of 23% diameter less than 10 μm (PM 10). Furthermore, this dust was highly contaminated with phosalone, an organophosphate pesticide that has been extensively used in the area (O'Hara et al. 2000).

Increased water salinity and pollutants have killed most of the Aral Sea fish, including all the native species (Bakhvalov 1997). Commercial fishing catches fell from 43,430 metric tons in 1960 to 17,460 metric tons in 1970 to non-existent in 1980 (Glantz 1999). Stalinization has damaged over 6 mil hectares of land (Glantz 1999). Effects include decreased vegetation for forage that has led to a decrease in the numbers of domestic animal numbers that can be supported (Okda 2001).

The drying up of the Aral Sea has impacted on the local climate. Previously, the Sea played a moderating role. Loss of the Sea is leading to shorter, drier summers, longer, colder winters, and decreased precipitation (Glantz 1999). Reduced growing seasons are contributing to decreased agricultural productivity.

Health in the Aral Sea region

The decline of the Aral Sea has been associated with the loss of thousands of jobs, especially in fishing related activities. Made worse by the loss of support from the former Soviet Union, the local economy has been annihilated. Correspondingly, the health status of the population has also decreased precipitously (Ataniyazova et al. 2001a).

The infant mortality rates in the Aral Sea region are said to have increased from about 25 per 1000 live births in 1950 to 70-100 per 1000 in 1996 (Zetterstrom 1999). In parts of Karakalpakstan, the infant mortality rate is over 100 per thousand (Bakhvalov 1997). Low birth weight, growth retardation, delayed puberty, and psychoneural retardation are all considered to be much more prevalent than normal (Zetterstrom 1999). Acute respiratory diseases account for almost one half of all child deaths, whilst diarrhoeal diseases rank second (MSF 2001).

The incidences of many diseases are increasing. Water borne infectious diseases including typhoid, hepatitis A and diarrhoeal diseases have caused massive outbreaks (Glantz 1999; MSF 2001). Tuberculosis and respiratory diseases are severe problems (Small et al. 2001). Malnutrition and anaemia are at very high rates (Ferriman 2000; Ataniyazova et al. 2001a). Liver and kidney diseases are becoming more common, as are some types of cancer, particularly of the liver and oesophagus (Glantz 1999; Ataniyazova et al. 2001b).

The leading causes of morbidity and mortality in the region are the sort of problems that occur in a population suffering upheaval, dislocation and poverty (Small et al. 2001). The hospitals and health centres in the Aral Sea region lack essential medicines and equipment, and thus struggle to ameliorate the effects of disease (Small et al. 2001).

Disease may also be more directly due to the effect of toxic chemicals on humans. Organochlorine pesticides, polychlorinated biphenyls (PCBs) and dioxins have been found at very high levels in blood and breast milk (Hooper et al. 1997; Jensen et al. 1997; Mazhitova et al. 1998; Ataniyazova et al. 2001b). The organochlorines derive from the massive amounts of the Russian-made pesticides used on the cotton fields over the preceding decades. They may enter people via several routes; ingested with food having bioaccumulated in the food chain, in contaminated drinking water, along with dust storms generated from the former seabed, in utero and with breast milk. DDT and HCH (Lindane) have been found in children at very high levels. Lindane may be applied on cotton five times during the growing season and is also used as a sheep dip twice a year (Ferriman 2000). The HCH included high levels of the β-isomer, which is a contaminant with a much higher biological stability than the α-isomer that

makes up Lindane (Ataniyazova et al. 2001b). In most developed countries, Lindane consists only of the α-isomer (Jensen et al. 1997). PCBs may have derived from industry far upstream. They may also have been added to pesticides in order to delay their evaporation (Jensen et al. 1997). The dioxins found included the highly toxic compound 2,3,7,8-tetrachlorodibenz-para-dioxin (TCDD) at levels amongst the highest ever recorded in the world (Ataniyazova et al. 2001b). The patterns suggest that their occurrence derives from being a contaminant of other products, most notably impure formulations of the herbicide 2,4,5 trichlorophenoxyacetic acid. This product was used as a defoliant in the Vietnam War (agent orange) (Jensen et al. 1997; Ataniyazova et al. 2001b).

It is not clear to what degree toxic chemicals are directly affecting human health. Organochlorines, including DDT and HCH, bioaccumulate and have been well characterised as causing immune toxicity as well as endocrine disruption during gestation, lactation and adulthood in laboratory and domestic animals and wildlife (Ataniyazova et al. 2001b; DEH 2001a). The dioxin 2,3,7,8-TCDD also bioaccumulates and is known to have a variety of toxic effects on humans and animals. Exposure has been shown to increase the risk of several types of cancer in humans (DEH 2001b). Large exposures may cause skin effects, most notably chloracne and other rashes, excessive body hair, plus liver and kidney damage (DEH 2001b). PCBs also bioaccumulate, reduce the capacity of mammals to reproduce and are likely to be carcinogenic (DEH 2001c). An outbreak of PCB poisoning occurred in Kyushu, Japan due to the ingestion of rice oil contaminated with a PCB mixture. The most common clinical symptoms were acneiform eruptions, gastro-intestinal disturbances and lethargy (Zetterstrom 1999; DEH 2001c).

Shortage of drinking water has become a serious problem in the Aral Sea area. High levels of salts have affected the water meant for human consumption (Small et al. 2001). Whilst there is little data on the health effects of chronic consumption of heavily mineralised water, it seems likely that it may contribute to the increasing incidences of kidney and liver disease in the region. The drinking water may be characterised as being of insufficient volume and contaminated with disease-causing microbes, high salt levels and toxic chemicals.

Studies have consistently shown associations between exposure to airborne particles and respiratory illnesses (Abrahamson and Beer 1998). The dust storms that come off the former seabed are laced with salts and toxic chemicals. This has created an airborne health risk unique to the Aral Sea environmental disaster and is likely to be a significant contributor to the populations' ill health, especially the high incidence of respiratory diseases.

It is not clear what the relative importance is of each of the factors that are impacting on the region's health. It is likely that they interact in complex ways to create the poor health outcomes being observed. What is clear, however, is that people in the area are suffering the effects of an environmental health crisis.

Vozrozhdeniye Island

Vozrozhdeniye Island (translates to Renaissance Island) is located in the middle of the Aral Sea. A secret facility for testing the Soviet Union biological warfare programme operated there from 1954 to 1992 (Bozheyeva et al. 1999). Tests were performed with smallpox, plague and anthrax, including open-air tests of anthrax bomblets (Tucker 1999). Towards the end of the Soviet era, hundreds of tons of anthrax were transferred from other facilities to Vozrozhdeniye Island. There the anthrax was buried in drums, or sometimes simply sandy pits and bleach added (Tucker 1999). Over recent years, US inspectors have visited the site and have found that some of the anthrax spores are still viable (Bozheyeva et al. 1999). With the waters of the Aral Sea receding, the island has grown from around 180 km^2 to 1800 km^2, and is now separated from the mainland by about 2 km of shallow water. There will eventually be a land bridge, which increases the possibilities of buried anthrax being disturbed, for example by rodents, and subsequently spread to the mainland to infect herbivores and people. The exploitation of Vozrozhdeniye Island for biological warfare experiments and as a dumping ground for unwanted anthrax, has created an additional man-made health risk for the people of the Aral Sea region.

Responses to the environmental disaster

Various people within the Soviet Union and outside it were able to predict the environmental disaster at least as early as 1956 (Glantz 1999). Changes in the Aral Sea and the deltas were clearly noted during the 1960s. Environmental concerns did not dissuade the decision-makers at the highest levels in Moscow. Stalin, Khruschev and Brezhnev all pursued policies of increased cotton production in

Central Asia, and hence increased irrigation and monoculture (Glantz 1999). Quotas were set and targets committed to, with scant regard for long term environmental consequences.

As the Aral Sea began to dwindle, Soviet and Central Asian officials pursued plans to transfer Arctic-bound river flows from Siberia to the Aral Sea Basin to increase the volume of water available for irrigation. These ambitious and environmentally risky plans have never eventuated (Glantz 1999; UNESCO 1999). Irrigation, however, has continued unabated.

The disintegration of the Soviet Union in December 1991 led to the creation of five newly independent Central Asian nations. Scarce water resources became a subject of competition between nations desperate for income that could be derived from cotton. Despite the devolution of power that occurred, the Aral Sea remained relatively remote from the controlling governments. The capital cities of each of the surrounding nations are at least 800 km from the Sea. The people of Karakalpakstan perhaps have reason to believe their problems are not being taken seriously by the central government (Hinrichsen 2000). Data has become scarce and unreliable and is often used as a political tool (UNESCO 1999). Recently, Kyrgystan asked Uzbekistan and Kazakstan to start paying for the water that emanates from Kyrgystan without success (Weinthal 2000).

Several organizations have been formed amongst the Central Asian nations with the aim of tackling water issues in relation to the Aral Sea, including the Interstate Council on the Aral Sea Basin Problems (ICAS), and the International Fund for the Aral Sea (IFAS) (UNESCO 1999). Due to limited finances and lack of clarity in their roles and activities, little has been achieved (Weinthal 2000). The United Nations Educational, Scientific and Cultural Organization (UNESCO) appointed a Scientific Advisory Board for the Aral Sea Basin (SABAS). Its vision document took a basin wide approach over five countries and gave little attention to the immediate health problems of those most suffering from the disaster, i.e. those closest to the Aral Sea, such as in Karakalpakstan. A list of goals was recorded and some scenarios were modelled, but it did little to address issues such as the financial realities and cotton monoculture. The vision document contained little sense of the need for immediate action (UNESCO 1999).

Health Responses

Medecins sans Frontieres (MSF) has been operating in the Aral Sea area since 1997 (MSF 2001). Its three main areas of activity are a tuberculosis programme, operational research and advocacy. Operational research refers to a community-based approach that focuses on multiple exposures and outcomes. The aim is to develop insight and understanding of the local environment, as opposed to the academic scientific model of hypothesis testing research with a focus on single exposure-outcome pathways (Small et al. 2001). This approach seems particularly suitable to the health problems of Aral Sea region, where fully understanding cause and effect is problematic and the need to assist is urgent. Current operational research subjects, carried out in conjunction with other MSF activities, include:

1. The relationship between airborne dust and respiratory disease.
2. The relationship between water salinity and hypertension and kidney stones.
3. Examination for toxic chemicals in the food chain.
4. Surveys of food security.

The US government has committed to making Vozrozhdeniye Island safe. As well as reducing the risk of the various infectious diseases contaminating the surrounding mainland, they have reduced the possibility of the organisms being accessible to others for nefarious uses and have obtained some military intelligence (Bozheyeva et al. 1999).

The Future

The restoration of the Aral Sea to as it was pre-1960 has long ceased to be a goal of the governments of Central Asia. This is because it would mean substantial reductions in irrigation that would have social and political consequences that they would not be prepared to contemplate (UNESCO 1999; Weinthal 2000; Stone 2001). Stabilisation of the Aral Sea at current levels would require very large efforts by the five Aral Sea Basin nations and is unlikely to occur. Plans to divert rivers from Siberia are unlikely to be reactivated.

In the last decade, the Aral Sea has separated into two bodies, the Small Aral Sea in the northeast fed by the Syr Darya, and the Large Aral Sea fed by the Amu Darya. Attempts are being made by Kazakhstan to stabilise the Little Aral, and hopefully restore it to a degree that allows native fish to return and fisheries be reactivated (Glantz 1999; Stone 2001). Whilst there is some reason for optimism

for the Little Aral Sea, the Large Aral Sea, is destined to continue to shrink and will soon break up into smaller, highly saline bodies of water. Efforts are being made to restore and preserve parts of the once massive Amu Darya Delta. Projects to save lakes and wetlands within the delta are being undertaken by the government of Uzbekistan with assistance from the government of the Netherlands (UNESCO 1999; Stone 2001). Global warming plus surface dusts on mountain glaciers, from where the Aral Sea waters originate, are likely to lead to a decline in these glaciers. This may further decrease the river flows.

Discussion

Current efforts to mitigate the environmental disaster are worthwhile but small in scale when compared to the total picture. Overall, the situation is likely to deteriorate for the people in the region of the Aral Sea. Water is likely to become scarcer and remain contaminated with microbes, salts and toxic chemicals. More of the seabed will be exposed and more toxic dust will be blown around the region. Stalinization of the soils will continue. In short, their health and wellbeing is likely to erode further as the region further loses its ability to sustain human life.

The five newly independent nations of the Aral Sea Basin still have an imperative to maintain high levels of cotton production, and hence irrigation, to support their economies. Thus, the people of the Aral Sea, who first had their environment sacrificed by the Soviet central command economy, are now having their problems aggravated by competing governments battling in a globalised market economy.

It is clear that the people of the Aral Sea require increased assistance from the rest of the world. While the problems of the Aral Sea have become well known, relatively little has been done to provide practical assistance to those most in need. Perhaps the current conflict and instability in Afghanistan will create greater geopolitical incentives for western countries to assist in Central Asia. Effective assistance in the areas of health and the environment would undoubtedly be much appreciated.

Assistance must be immediate, practical and impact at a local level. Consultation must occur with those who are to be the recipients of aid to ensure that efforts are properly directed. Aid from different sources should be well co-ordinated to make their activities synergistic rather than competing. Research would best be commenced in conjunction with practical assistance, rather than precede it. The MSF approach to operational research should be educative to those who seek to help the people of the Aral Sea area. There is much that could be done to improve the fast decaying health infrastructure in the area.

The effectiveness of Aral Sea Basin organizations responsible for water management, such as the IFAS, should be supported. Donor nations should work with the appropriate body to ensure interventions are suitable for all stakeholders, roles are clear and the bodies empowered. These bodies should ensure they include stake- holders from the immediate vicinity of the Aral Sea, such as Karakalpakstan. Finding ways to reduce each nation's dependence on cotton production may be a useful objective.

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