Preliminary Field & Lab Report

DARBANDIKHAN LAKE POISONING EVENT

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This preliminary report is prepared to summarize and inform partner agencies on biological and water quality investigations performed by Nature Iraq on waters at Darbandikhan Lake in Kurdistan, Northern Iraq. For more information please refer to Nature Iraq's web site: www.natureiraq.org or write to:

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Introduction

Darbandikhan Lake is one of the three large lakes in Kurdistan, Northern Iraq, 230 km northeast of Baghdad. It is fed by two main tributaries: the Tanjero River, which flows in from the north/northwest, and the Sirwan River, which flows in from the east (from Iran).

This and the surrounded area is a biological diverse area for wildlife and listed as an Important Bird Area in Iraq by BirdLife International. Many people benefit from this lake and its waters as it is used as a source for drinking and irrigation water, as an important fisheries, and as a beautiful site used by many for recreation. It is also an important source of electricity generated by the Darbandikhan Dam.

Darbandikhan Lake is currently at a high risk due to pollution by sewage and municipal wastes. Its water levels are threatened by the current severe drought affecting the region as a whole and by work in Iran to install a dam on the Sirwan River. Other dams have been constructed (the Chaq Chaq Dam near Sulaimani, which was built in 2005 and subsequently broke in the spring of 2006 due to design failures) or are proposed (an irrigation dam in the Qara Ali area along the Tanjero between Sulaimani & the lake).

Poisoning Event & NI Response

Recently another threat was seen on the river. Nature Iraq (an environmental non-governmental organization based in the city of Sulaimani) was informed that there were many fish killed in the Lake when some people put poisons into the water near Jardasna Village on the 30th of July.

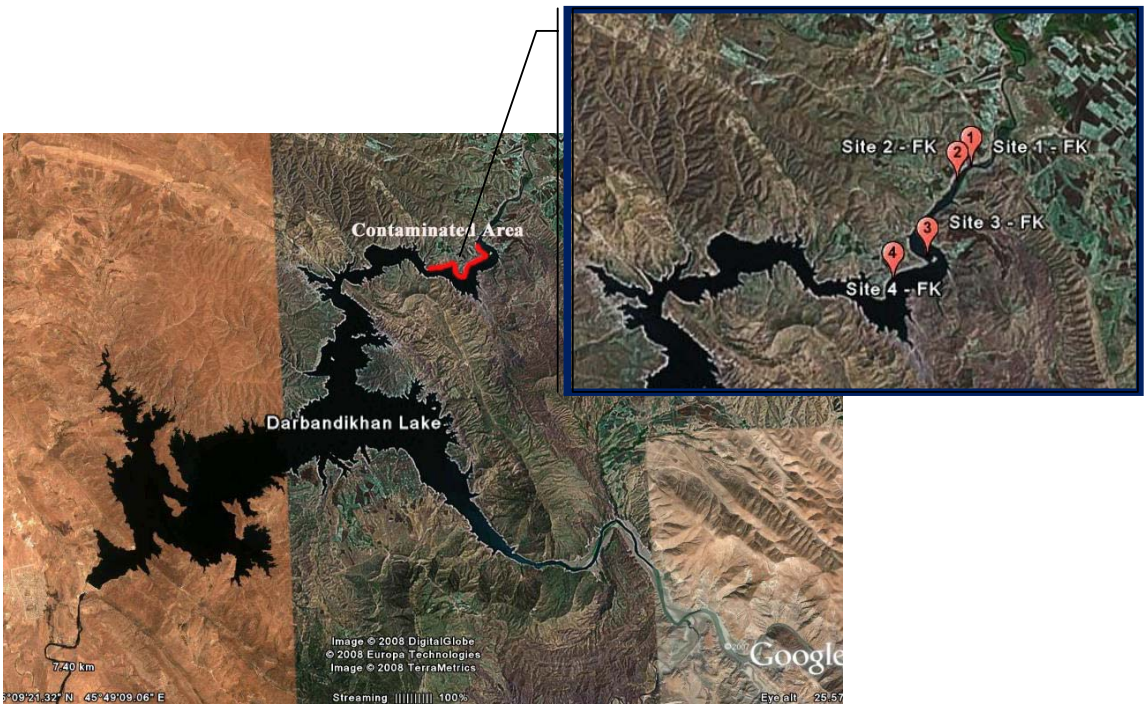

Plate 1: Map of Darbandikhan by Google Earth, showing area where contamination may have occurred and four sample points visited by this survey

A team from Nature Iraq went to investigate the situation on 13 August and when they arrived they found many dead fish and other creatures such as turtles as well as strong odours from the decaying organisms along more than three kilometres of the shoreline (This is indicated on the map above in red). It was estimated that more than one million fish were killed.

Plate 2 & Plate 3: Photos from first Nature Iraq Site visit on 13 August

Then on 14th of August (the second day of investigation), Nature Iraq sent another team to investigate as well as take samples from the affected area. Site condition had deteriorated with more dead fish seen as well as a dead bird (see photos below). This is a indication of human-induced stress to the ecosystem.

Plate 4 & Plate 5: Photos from second Nature Iraq Site visit on 14 August

Results of Field Reconnaissance & Lab Analysis

On 14-Aug-2008 at 1 pm, the Nature Iraq field team visited what was considering the most damaged sites caused by the poisoning event. The team contained four specialists from different fields of expertise (Haider Ahmed Falih, Ali Mohammed Maher, Raid Abdul Mehdi for Water quality & Sediments and Korsh Ararat for birds and other biota). They took the basic field measurements, collect water, sediment and fish samples and noted some important field observations.

The following represents the results of this field work and the field measurements collected and basic water quality, sediment, and fish analysis. Water and fish samples were sent to Basrah for testing of hydrocarbons (also included in this report).

Site 1: N 35 13 .3 E 45 51 37.64

Site Description: It is near a destroyed bridge, 2.13 km north (upstream) of Site 3 - the water appeared to be the cleanest at this site -the source of water are the Tangero, Zalm and various smaller drainages to the north. The site had relatively high flows and normal water conditions were observed but also high turbidity; no dead fish were seen but a few hundred meters to the south a few dead fish were observed and they look somewhat old, possibly killed during the first days of the incident. The results of preliminary analysis are included in the table below for Site 1.

Table 1: Water Quality Field and Lab Results for Site 1

#	Field Measurements		Lab Results	
1	pH	7.95	Ca++ mg/L	80.15
2	TDS mg/L	289	Mg++ mg/L	91
3	Conductivity µs/cm	527	Cl^- mg/L	11.27
4	Salinity	ND*	SO4 mg/L	42.44
5	Water Temperature ºC	27.7	Total Hardness mg/L	290
6	Air Temperature ºC	43	TOC %	0.19
7	Turbidity NTU	176	Alkalinity mg/L	272.19
8	DO mg/L	7.93	PO4 mg/L	0.016
9	DO %	106.3	TP mg/L	0.060

*Not detected

Site 2: N 35 12 51.74 E 45 51 27.82

Site Description: This site is located approximately 1.71 km north (upstream) of site 3. Almost the same observations were recorded here, but the water was deeper at this location and oxygen levels were somewhat decreased; dead fish were seen but fewer than those seen downstream of Site 1. Water flow was less than at Site 1. Expectations were that pollution increased south of this site and decreased north of this site. The results of preliminary analysis are included in the table below for Site 2.

Table 2: Water Quality Field and Lab Results for Site 2

#	Field Measurements		Lab Results	
1	pH	7.78	Ca++ mg/L	80.95
2	TDS mg/L	288	Mg++ mg/L	91
3	Conductivity µs/cm	526	Cl^- mg/L	8.93
4	Salinity	ND*	SO4 mg/L	43.75
5	Water Temperature ºC	27.3	Total Hardness mg/L	293
6	Air Temperature ºC	44	TOC %	0.86
7	Turbidity NTU	115	Alkalinity mg/L	290.34
8	DO mg/L	5.48	PO4 mg/L	0.029
9	DO%	78.9	TP mg/L	0.100

*Not detected

Site 3: N 35 12 8.3 E 45 51 6.6

Site Description: This site is surrounded by mountains and the river here had a low water level (1-2 m). There was an island in the center of the river where locals had done some planting. The water was still and slightly green and the smell of the dead fish was very strong. Many different

lines of dead fish were found on the ground; each line represented possibly a different time of death or period in the poisoning event with the highest levels (furthest from the current water level) being the oldest. During this time of year, the water level of the lake is being affected by dam releases downstream and drought conditions. The general trend was a general lowering of the water level in the lake, which could be seen in these water level marks/debris lines left behind by the retreating water on the reservoir banks. The lower lines (closest to the current water level) were long, extending beyond the teams sight and represented thousands of dead fish. Some fish were still floating on the surface of the water but these were fewer in number. Other dead organisms such as turtles were found. Bubbles were seen coming out from the bottom of the water which may have affected the dissolved oxygen measurements. Water, sediment and fish samples were taken here before the team moved to Site 2, which was 1.71 km to the north of Site 3. The results of preliminary analysis are included in the table below for Site 2.

Table 3: Water Quality Field and Lab results for Site 3

#	Field Measurements		Lab Results	
1	pH	9.25	Ca++ mg/L	26.05
2	TDS mg/L	150	Mg++ mg/L	50
3	Conductivity µs/cm	276	Cl^- mg/L	8.92
4	Salinity	ND	SO4 mg/L	56.76
5	Water Temperature ºC	33.7	Total Hardness mg/L	115
6	Air Temperature ºC	42	TOC %	15.19
7	Turbidity NTU	22.6	Alkalinity mg/L	114.93
8	DO mg/L	Inconclusive	PO4 mg/L	0.046
9	DO%	Inconclusive	TP mg/L	0.087

*Not detected

Site 4: N 35 11 54.09 E 45 50 42.38

Site Description: The water quality at this site was extremely poor and there were long lines of dead fish along the shore, most of them larger in size than those found at the second or third site. They appeared to have died more recently as well. There were boats on both side of the river. Birds were seen, as the team approached the site, drinking from the water of the river. This site had the appearance of an open lake and the water depth differed at the site between 5 to 15 meters. The results of preliminary analysis are included in the table below for Site 4.

Table 4: Water Quality Field and Lab Results for site 4

#	Field Measurements		Lab Results	
1	pH	8.4	Ca++ mg/L	36.46
2	TDS mg/L	175	Mg++ mg/L	51
3	Conductivity µs/cm	290	Cl^- mg/L	8.71
4	Salinity	ND*	SO4 mg/L	62.5
5	Water Temperature ºC	33.5	Total Hardness mg/L	142
6	Air Temperature ºC	41	TOC %	0.70
7	Turbidity NTU	47.5	Alkalinity mg/L	120.98
8	DO mg/L	8.5	PO4 mg/L	0.01
9	DO%	127.9	TP mg/L	0.069

*Not detected

Heavy Metals in Water, Sediment & Fish

The results of test for heavy metals in water for the four sites at Darbandikhan Lake are presented below. They are compared to two surface water references (Kabata-Pendias and Mukherjee, 2007 & Agardy and Sullivan, 2005) and the World Health Organization Drinking Water Standard is included for additional contrast. Preliminary results for all sites indicate elevated levels of cadmium, manganese, lead and nickel in surface waters.

Table 5: Heavy Metals in Water for four sites in Darbandikhan Lake (August 2008)

Site Code	Cu ppm	Cd ppm	Mn ppm	Pb ppm	Zn ppm	Ni ppm
1	0.008	ND	**0.339**	**0.459**	ND	**0.193**
2	0.011	**0.002**	**0.361**	**0.418**	ND	**0.264**
3	0.011	**0.002**	**0.279**	**0.310**	ND	**0.206**
4	0.010	**0.005**	**0.283**	**0.354**	ND	**0.121**
Surface Water References*	0.27	0.000005	0.007-.5	0.09	N/A	0.0005-0.006
Drinking Water Reference**	2	0.003	0.4	0.01	1.1-3	0.02

*Kabata-Pendias and Mukherjee (2007) & Agardy and Sullivan (2005)
**WHO Drinking Water Standard (2006)

The results of test for heavy metals in sediment for the four sites at Darbandikhan Lake are presented in the table below and compared to Swedish standards for contamination levels (Swedish EPA, 2000), which showed elevated levels of Copper, Lead, Zinc and Nickel at some or all sites:

Table 6: Heavy Metals in Sediment for four sites in Darbandikhan Lake (August 2008)

Site Code	Cu ppm	Cd ppm	Mn ppm	Pb ppm	Zn ppm	Ni ppm	Fe ppm
1	0.011	0.009	0.427	0.037	0.066	**0.14**	**24.76**
2	0.038	0.022	0.918	**0.109**	**0.229**	**0.406**	**29.88**
3	**0.054**	0.02	0.999	**0.109**	**0.28**	**0.481**	**20.76**
4	0.037	0.013	0.805	**0.11**	**0.218**	**0.404**	**33.86**
Swd. Con.*	**0.04**	**0.04**	**NA**	**0.04**	**0.075**	**0.03**	**NA**

*Swedish Contamination level

Four (4) fish samples were taken from Site 3 and their tissues were tested for heavy metals. Samples were frozen after collection and muscle and bone tissue were taken from each fish to be tested by Flame Atomic Absorption Spectrometry (AAS).

Table 7: Metals in fish samples by Flame Atomic Absorpation Spectrometry (AAS) (Analysis performed on 8 December 2008).

Sample	Cd ppm	Cu ppm	Pb ppm	Fe ppm	Mn ppm	Zn ppm	Ni ppm
Sample 1	**1.3**	0.5	**4.4**	167.4	8.6	**100.8**	**5.5**
Sample 2	**2.6**	1.8	**6.2**	189.1	12.9	**107.5**	**7.8**

Sample	Cd ppm	Cu ppm	Pb ppm	Fe ppm	Mn ppm	Zn ppm	Ni ppm
Sample 3	1.9	0.5	11.2	213.6	15.7	115.5	5.7
Sample 4	1.5	0.2	3.6	199.1	13.8	132.1	2.8
Reference Standards for Daily Consumption	0.05[1] 0.06[2], [3]	20[2]	0.2[1], 0.21[2], 0.5[3]	NA	NA	50[2]	0.3[4]

[1]Eritrean MoF/FAO (2003)
[2]Joint Expert Committee on Food Additives of Food and Agriculture Organization (JECFA) Provisional maximum Tolerable Daily Intake (PTDI) (WHO, 1993)
[3]Commission of the European Communities (1997)
[4]WHO (1993) – based on consumption rates of 0.3 mg/day for a 60 kg person

Hydrocarbons in Water and Fish Samples

Surface water samples were taken and sent to the Marine Science Center Lab at the University of Basrah for hydrocarbon lab analysis. No reference standards are available at this time for comparison. The results are presented below.

Table 8: Hydrocarbon results for water samples

#	g/gµ
1	1.98
2	5.71
3	4.27
4	8.06

Two (2) fish from Site 3 and two fish from Site 4 were dissected and tissue muscle, backbone and head tissue & bone were sent for hydrocarbon lab analysis at the Marine Science Center Lab at the University of Basrah. Unfortunately, species identification, ages and weights were not noted so the results presented below remain preliminary. No reference standards are available at this time for comparison.

Table 9: Hydrocarbon results for fish samples

Name of point	Site number	g/gµ
Fish muscle tissue	Site 3	7.29
Backbone	Site 3	4.72
Head	Site 3	12.27
Fish muscle tissue	Site 3	4.95
Backbone	Site 3	1.81
Head	Site 3	6.94
Fish muscle tissue	Site 4	5.77
Backbone	Site 4	3.92
Head	Site 4	8.1
Fish muscle tissue	Site 4	15.42
Backbone	Site 4	16.37
Head	Site 4	10.23

Preliminary Conclusions

Many of the physical and chemical water parameters presented in this report will not provide much information in a potential poisoning event such as this. But the percentage of total Organic Carbon (%TOC) is a good indicator that a significant impact occurred. This parameter indicates the percentage of organic material at a site. It is clear that the %TOC for the first site was generally good and normal but for the others this was not the case and particularly the third site showed an extremely high %TOC than would usually be expected in such an incident and this is probably due to the dead fish and other organisms that increase the amount of organic material at the site.

The third site also shows an abnormally high pH value as well but the dissolved oxygen was perhaps an unreliable measurement affected by bubbles that were seen at this site on this first trip. The first site had almost the same measurements as the second site, while on the ground they appeared different – site 1 look like much cleaner than site 2.

There may be some preliminary information from the University of Sulaimani indicated that the main causes of the fish kill was high levels of mercury (Hg) and lead (Pb), these results make sense. After discussion of the Nature Iraq results for heavy metals, Dr. Abdul Hameed, a water quality expert from the University of Baghdad, indicated that these sites have abnormal concentrations of lead, which would usually come from external sources such as a factory or factories up stream (personal communication). Heavy metals in sediment were compared with a Swedish EPA contamination levels and showed that, in comparison to this standard, copper was elevated at site 3, lead was elevated in site 2, 3 and 4; zinc was elevated at sites 2, 3, & 4, and nickel was elevated in all sites. Sometimes these elevated levels were two, three or more times the Swedish standard indicating high levels of contamination in the sediments.

Heavy metals suspended in water are an indication of more recent exposure to heavy metal sources. As stated above, preliminary results for all sites indicate elevated levels of cadmium (Sites 2, 3, & 4), manganese, lead and nickel (all sites) in surface waters. In some cases these levels are many times higher than referenced information for surface water and also when compared to drinking water standards. It should be noted that that the lake water is being used for human consumption needs and more information and study is urgently needed.

For fish, unfortunately, species identification, age and weight was not done for either heavy metal testing or hydrocarbon testing, so the results included in this report remain preliminary. The results do indicate that fish in the Tanjero River/Darbandikhan Lake basin may have chronic exposure to cadmium, lead, manganese, zinc and nickel that may be reaching levels that pose serious health risks to humans and other biota that consume them. More in-depth study in needed and should be a high priority.

The preliminary results for hydrocarbon testing of water and fish samples but as stated above, suffered from deficiencies in data collection (species identification, age and weight values). In addition, Nature Iraq does not have reference standards to provide adequate comparison and interpretation of the results.

Recommendations

As noted above, the findings of this report, though limited in scope and preliminary in nature indicate that there are serious problems in the basin that go far beyond a single fish kill events. There is an urgent need for additional survey work and more comprehensive testing of water,

sediments and fish. It is also important to establish the sources of contamination to the lake and this will involve a more focused study of the basin as a whole and how pollutants both enter and move through it.

Upon completion of this survey work, additional surveys were conducted, including a survey of many of the industries within the Tanjero River Basin. These are the subject of later reports but this information, as well as historical information will be included in a database being developed by Italian experts with support of the Italian Ministry of Environment, Land and Sea. In additional a draft "State of the Basin" report is being developed. It should be noted that these are only preliminary steps towards addressing the problems of the Basin and urgent action is also needed, including the building of a waste water treatment plant and controlling and/or eliminating many of the pollution inputs to the basin.

References

Agardy ,F.J., Sullivan, P., Clark, J. J. (2005). The Environmental Science of Drinking Water. Elsevier Science & Technology Books. p.357.

Eritrean MoF (Ministry of Fisheries)/FAO (Food & Agriculture Organization). (2003). Heavy Metals Regulations Legal notice No. 66/2003, Part 1, Preliminary. Ahmed Haj Ali, Eritrea: Ministry of Fisheries.

European Union (2001). Commission Regulation (EC) No 466/2001 setting maximum levels of certain contaminants in food stuffs. Official Journal of the European Communities. L77/1.

FAO/WHO. (1976). List of maximum levels recommended for contaminants by the Joint FAO/ho CODEX ALIMENTARIUS COMMISSION. Second series. CAC/FAL., Rome, 3:1-8.

Kabata-Pendias, A., Mukherjee, A.B., (2007). Trace Elements from Soil to Human. Springer, Berlin. p.550.

Swedish Environmental Protection Agency. (2000). Metals in Lakes and Water Courses. Retrieved in November 2008 from http://www.internat.environ.se.

WHO (World Health Organization). (1993). Evaluation of certain food additives and contaminants. Thirty seventh report of the Joint FAO/WHO expert committee on food additives.

WHO (World Health Organization). (2006). World Health Organization, Guidelines for Drinking-Water Quality. 3rd edition., Vol.1.