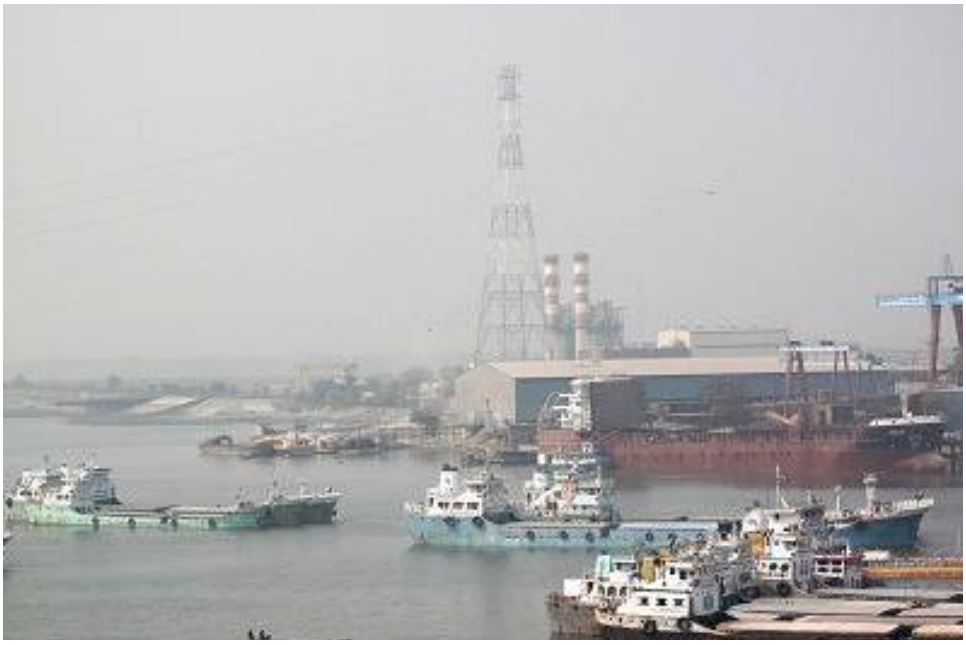


Hazaribag and Gazaria
Potential Mercury Hot Spots in Bangladesh

Report by
ESDO
Arnika Association
and IPEN

Dhaka - Gothenburg – Prague - July 2013

Hazaribag and Gazaria – a Potential Mercury Hot Spots in Bangladesh

IPEN Mercury-Free Campaign Report

Prepared by Environment and Social Development Organization – ESDO (Bangladesh), Arnika Association (Czech Republic) and the IPEN Heavy Metals Working Group

Dhaka, Prague, Gothenburg – 5 July 2013

Introduction

In 2009, the Governing Council of the United Nations Environment Programme (UNEP GC) decided to develop a global legally binding instrument on mercury to reduce risks to human health and the environment (UNEP GC25/5). The UNEP GC noted that mercury is a substance of global concern due to its long-range transport, persistence, ability to bioaccumulate, and toxicity. Its conclusions were based in part on the 2002 UNEP Global Mercury Assessment which noted that mercury is present in fish all over the globe at levels that adversely affect humans and wildlife. (UNEP 2002) Mercury is present in different forms but the organic form of mercury, methylmercury, is especially toxic to humans and wildlife because it is readily absorbed by the body and accumulates in blood and tissue. In humans, hair is widely accepted as a matrix for reliable estimations of the body burden of methylmercury, which likely comes from eating fish (Grandjean, Weihe et al. 1998); (Harada, Nakachi et al. 1999); (Knobeloch, Gliori et al. 2007); (Myers, Davidson et al. 2000).

This report focuses on industrial areas in Munshiganj district and Hazaribag landfill site, both near Dhaka City.

Materials and methods

National NGO *Environment and Social Development Organization (ESDO)* conducted fish and hair sampling in Munshiganj district and Hazaribag, Dhaka. In total fifteen were caught in collaboration with local fisherman using protocols developed by the Biodiversity Research Institute (BRI 2011). Fourteen fish samples were taken from Meghna River near Jamaldi, Gazaria upazila and one fish sample of African catfish comes from Hazaribag, Dhaka. ESDO conducted sampling of human hair in Munshiganj district and Hazaribag, Dhaka using protocols developed by IPEN (2011). Fifteen hair samples were taken in total for this study. Biodiversity Research Institute (BRI) measured mercury levels (total mercury content = THg) in both fish and hair samples in their laboratory in Gorham, Maine, USA. ESDO characterized the studied area and provided information about its history and presumptive mercury sources.

Industry in Munshiganj district

There are several cement plants in studied area of Munshiganj district either on the Meghna River banks or on the islands in middle of the river itself. Shah Cement Factory, Mukterpur, Munshiganj is the pioneer in cement industry in Bangladesh. Meghna Group of Industries has entered into the Portland Cement. It has 2 factories: Factory 1 is Unique Cement Industries

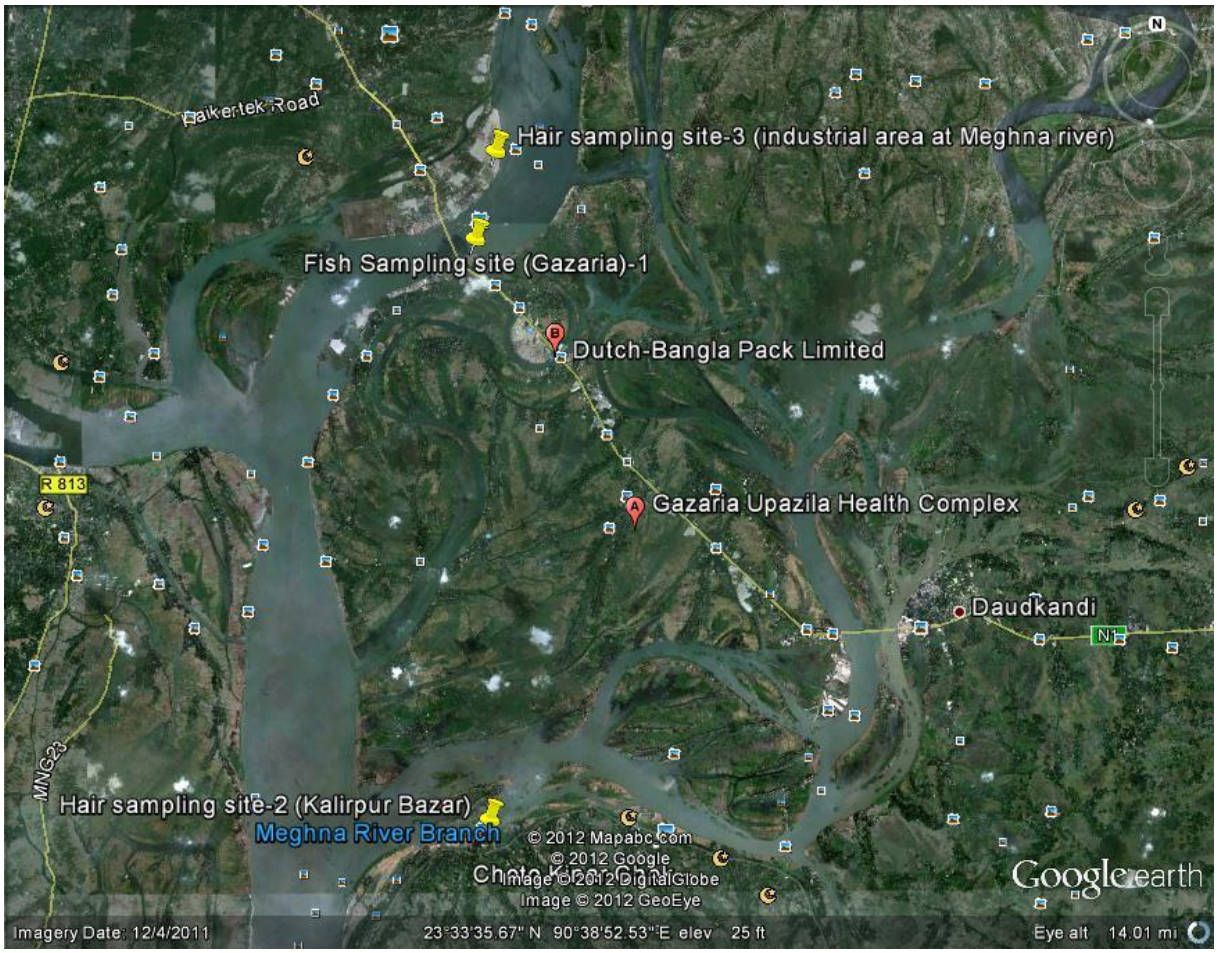
Limited with production capacity of 3400 Mt per day, established in 2001 and factory 2 is Fresh Cement Industries Limited with production capacity of 4000 Mt per day, established in 2010 situated very close to chemical industry (chlor-alkali plant described below).

On the same side of Meghna River on the island under the bridge is also located paper mill and some other industries.

All above mentioned industries are potential sources of mercury pollution.(UNEP Chemicals 2005)

Picture 1: Map of Munshiganj district with marked Gazaria upazila. Bridge under which samples were taken is on the red line (road) crossing Meghna River, north-east on this map.

There is also chlor-alkali plant of Samuda Chemical Complex Limited, in Sikirgaon, Gazaria, on the eastern bank of the Meghna River, north from the bridge. It uses diaphragm process for production of chlorine, so it cannot be considered as large source of mercury, because Hg is not involved in this type of chlor-alkali plant, however we do not have information about other potential uses of Hg in follow up processes in this factory and/or its energy source.



Picture 2: Google Earth map shows sampling sites. Industrial area with paper mill and one cement factory is on island under north end of the Meghna River bridge in the upper part of this map (with hair sampling site – 3).

Hazaribag hazardous waste landfill

There is an uncontrolled landfill site for mixed municipal and hazardous waste in Hazaribag on the west from Dhaka, a capitol city of the Bangladesh (see map at Picture 3). Regarding hazardous wastes there is disposed off mainly waste from tannery and health care sector at the landfill in Hazaribag. The waste is being disposed off mainly on lowland very close from the corporation areas which are operated in uncontrolled manner without any proper earth cover and compaction. This landfill site can be potential source of mercury releases into both air and water especially due to content of medical waste and potentially also batteries and other hazardous wastes containing mercury from households.

Picture 3: Google Earth map with Hazaribag waste landfill and hair sampling site location.

Results and discussion

For this study, seven fish species were sampled from two different localities. Only one African catfish sample was caught in the lagoon in Hazaribag, while the rest of 15 fish samples were caught in Meghna River under the bridge near Jamaldi, Gazaria upazila (see map). Table 1 shows overview of all species and size of fish. Nine samples of barramundi perch were caught while for other species we obtained only one sample per species, what can limit results of this study. Another limiting factor is that barramundi perch is migratory fish and as it is shown in table 1 we obtained only fish samples of juvenile or nearly juvenile size, so we can expect that all sampled fish of barramundi perch most likely will not reflect levels of mercury in Meghna River at studied site, but rather levels in near salt waters (sea). Moore and Reynolds who studied barramundi perch at Papua New Guinea concluded that juveniles remain in salt water until they are 200–300 mm in length before they migrate to fresh waters (Moore and Reynold 1982). Another study stated that *„Barramundi are known to feed more heavily on fish as they grow, switching from a diet dominated by macrocrustaceans as juveniles (80-400 mm total length) to a diet dominated by fish as adults (>400 mm) (Pusey et al., 2004),“* (Jardine, Halliday et al. 2012). So we most likely got samples of barramundi perch which did not prey on other fish too much yet.

We have compared also size of other fish species with data published at www.fishbase.org in order to get better picture about size of fish samples caught in Meghna River for this study. They can be found in notes below Table 1.

Table 1: Overview of fish species caught in Meghna River Mercury content of fish sampled in Meghna River and Buriganaga River, Bangladesh in ppm wet weight.

Fish species – English name	Fish species – Latin name	No of samp.	Length range (mm)	Weight range (g)	Min Hg (ppm d.w.)	Max Hg (ppm d.w.)	Note
African catfish	Clarias graiepinus	1	590	1500		0.032	1)
Barramundi perch	Lates calcarifer	9	340-397	472-758	0.076	0.174	2)
Long whiskered catfish	Sperata aor	1	590	1080		0.482	3)
Great snakehead	Channa marulius	1	580	1270		0.685	4)
Snakehead murrel	Channa striata	1	415	608		0.698	5)
Wallago	Wallago attu	1	840	2867		1.139	6)
Pangas catfish	Pangasius pangasius	1	490	1216		0.014	7)

Abbreviations: Hg, mercury; ppm, parts per million or mg/kg; ww, wet weight; min, minimum; max, maximum
Notes: 1) African catfish – normal length 90 cm, maturity from 34 cm
(Binohlan and Geelhand).
2) Barramundi perch - juvenile size (Jardine, Halliday et al. 2012) or nearly to juvenile size (Bowles, Apte et al. 2001) samples only in comparison with normal length of fish according available literature
3) Long whiskered catfish – normal length 100 cm (Binohlan and Luna)
4) Great snakehead – common length 46 cm (Luna b)
5) Snakehead murrel – common length – 61 cm, maturity from 23 cm (Luna)
6) Wallago attu – common length 75 cm (Capuli and Torres)
7) Pangas catfish – max. length 300 cm, maturity from 63 cm (Froese and Sampang)

Table 2 shows that all mercury levels in barramundi perch from Meghna River were below the US EPA reference dose. Only sample of wallago fish with mercury level of 0.247 ppm ww exceeded this reference dose. This fish sample was rather bigger fish in comparison with normal size of this species fish (see Table 1 with notes).

Table 2: Mercury content of fish sampled in Meghna River, Bangladesh in ppm wet weight.

	Sample Size	Hg Average (ppm, ww)	St Dev	Min Hg (ppm)	Max Hg (ppm)	Reference dose[a] (ppm)	Fraction of samples over Ref. Dose
Barramundi perch	9	0.029	0.006	0.017	0.038	0.22	0%
All fish samples (Meghna River only)	14	0.075	0.085	0.007	0.247	0.22	7%
All other than barramundi perch fish samples	5	0.158	0.099	0.007	0.247	0.22	20%

Abbreviations: Hg, mercury; ppm, parts per million or mg/kg; ww, wet weight; min, minimum; max, maximum

[a] Figure derived from the reference dose used as U.S. EPA consumption guidelines for fish (0.2 $mg.kg^{-1}$ methylmercury) based on the presumption that methylmercury counts for 90% of THg levels, limit value used by Canada is similar . Japan and/or UK use 0.3 reference dose. Source: US EPA (2001). Water Quality Criterion for the Protection of Human Health: Methylmercury. Final. EPA-823-R-01-001, Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency Washington, DC**:** 303.

Table 3: Mercury content of fish sampled in Meghna River, Bangladesh (in ppm dry weight), in comparison with some previous studies. African catfish sample is from Hazribag caught in the lagoon of Buriganaga River. 2008 – source: (Sharif, Alamgir et al. 2008b), 2009 – source: (Sharif, Alamgir et al. 2009).

	Sample Size	Hg Average (ppm, dw)	St Dev	Min Hg (ppm, dw)	Max Hg (ppm, dw)
All fish samples – Meghna River (this report)	14	0.299	0.328	0.014	1.139
All other than barramundi perch fish samples – Meghna River (this report)	5	0.604	0.408	0.014	1.139
Barramundi perch (this report)	9	0.129	0.031	0.076	0.174
Barramundi perch (2008)		0.377	0.072	0.29	0.45
Wallago (this report)	1				1.139
Wallago (2008)		0.223	0.034	0.18	0.25
Snakehead murrel (this report)	1				0.698
Snakehead murrel (2008)		0.475	0.0645	0.40	0.55
African catfish (this report)	1				0.032
African catfish (2009)		0.858	0.046	0.80	0.91

Abbreviations: Hg, mercury; ppm, parts per million or mg/kg; dw, dry weight; min, minimum; max, maximum

There are available data about mercury levels in fish from Bangladesh measured in previous years, however they are not expressed in ppm wet weight, but in ppm dry weight. Table 3 shows levels of mercury in fish in this study and compares them with older studies from Bangladesh, if available. Sharif, Alamgir et al. studied mercury levels in extensive number of fish samples in 2008 and these results were published in several articles (Sharif, Alamgir et al. 2008); (Sharif, Alamgir et al. 2008b); (Sharif, Alamgir et al. 2009).

Length of sampled barramundi perch varied between 340 and 397 mm and weight 472 – 752 g in this study. There is no available data about length of fish analyzed by Sharif, Alamgir et al. (2008b), however they mentioned in the article that size of the fish was taken into the records. We cannot compare effectively data obtained in this study with results from 2008, because our barramundi perch samples were juvenile or nearly juvenile as we demonstrated on comparison with other studies (Jardine, Halliday et al. 2012); (Bowles, Apte et al. 2001). We anticipate that mercury levels in barramundi perch in this study were lower, because of the size and most likely younger age samples in comparison with study from 2008.

Table 4 shows the levels of mercury (Hg) in hair samples from Gazaria (10 samples) and Hazaribag (5 samples) larger areas. The average level of THg in the hair of all 15 volunteers from was below the US EPA reference dose. Higher average level of mercury was observed among volunteers from Gazaria upazila. Two samples, one from Gazaria and one from Hazaribag, exceeded US EPA reference dose. Highest level of mercury (2.678 ppm) was in hair of 55 years old fisherman.

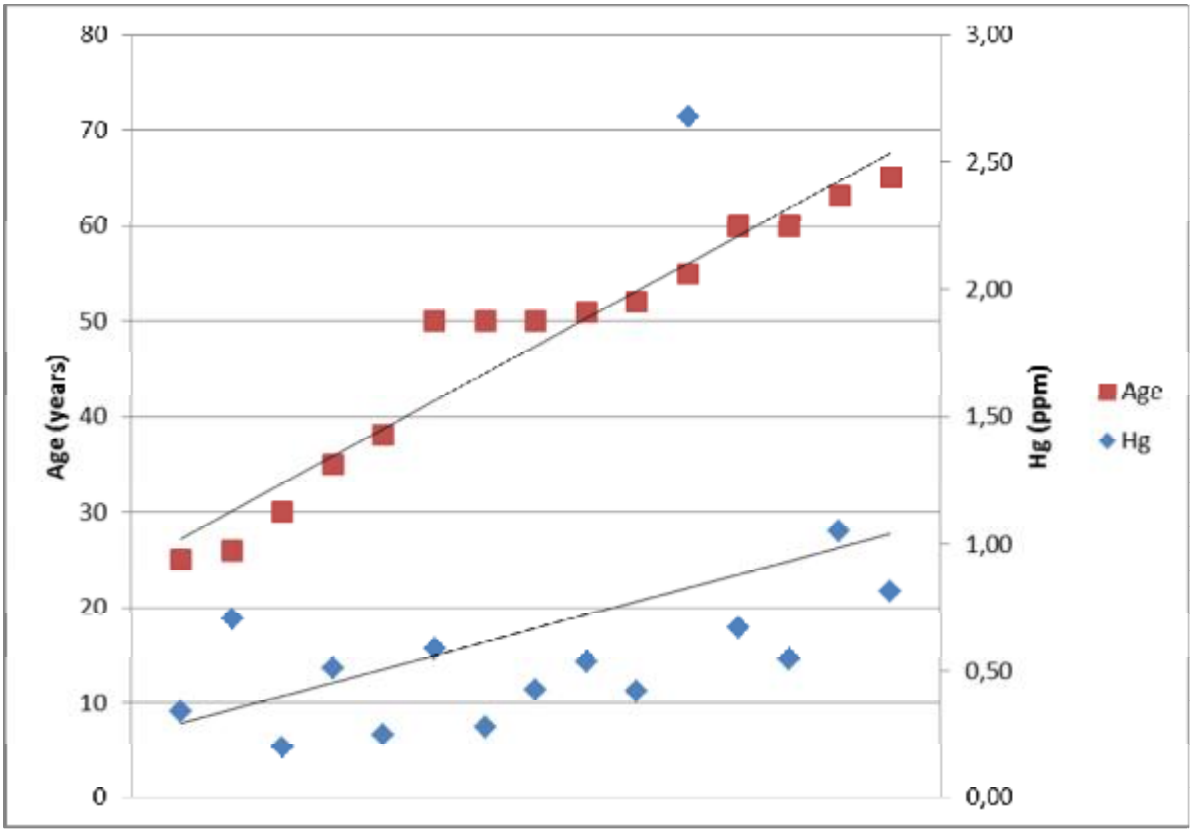
Graph at Picture 4 shows relationship between the age of volunteers and THg in their hair. It is clear that age is most significant reason for increased levels of THg in this group what is observation for some populations in other studies as well (Agusa, Kunito et al. 2005); (Airey

1983); (Yasutake, Matsumoto et al. 2004); (EARTH, Arnika Association et al. 2013), however other criteria like the portion of fish and composition of fish species in diet may play important role as well.

Table 4: Mercury content in hair samples from Gazaria and Hazaribag larger area.

	Sample Size	Hg Mean (ppm)	St Dev	Min Hg (ppm)	Max Hg (ppm)	Reference dose (ppm)[b]	Fraction of samples over Ref. Dose
Gazaria, Munshiganj	3	1.310	1.185	0.586	2.678	1.00	33%
Motlab, Chandpur	5	0.474	0.222	0.198	0.811	1.00	0%
Munshiganj	2	0.625	0.109	0.548	0.702	1.00	0%
Hazaribag	5	0.491	0.331	0.252	1.050	1.00	20%
Gazaria upazila – all hair samples	10	0.755	0.697	0.198	2.678	1.00	10%
All hair samples	15	0.667	0.600	0.198	2.678	1.00	13%

Abbreviations: Hg, mercury; ppm, parts per million or mg/kg; st dev, std deviation; min, minimum; max, maximum



Picture 4: Graph of relationship between age of volunteers and THg levels in their hair from Gazaria upazila and Hazaribag, Dhaka in Bangladesh.

[b] U.S. EPA's RfD is associated with a blood mercury concentration of 4-5 µg/L and a hair mercury concentration of approximately 1µg/g." US EPA (1997). Mercury study report to Congress, Volume IV, An assessment of exposure to mercury in the United States. EPA-452/R-97-006**:** 293.

Holsbeek, Das et al. (1996) studied levels of mercury in hair of population in whole Bangladesh in 90-ies of 20th century. Average level of THg in hair of volunteers in this study is higher than they observed, however number of analyses in that study was much larger (219 in total) than in this study (15 in total). Also maximum level observed in Gazaria (2.678 ppm) was much higher than maximum level in study from nineties (0.95 ppm). Levels observed in Hazaribag in this study were at the same average level observed among group from Dhaka by Holsbeek, Das et al. (1996), however maximum mercury (1.050 ppm) level among volunteers from Hazaribag in this study was higher than in comparable group from Dhaka (0.56 ppm) studied in 90-ies.

Holsbeek, Das et al. (1996) concluded in regards to low levels of mercury they found in hair of Bangladeshi population that: *"… important … seems to be the heavy rainfall and annual flooding of greater parts of Bangladesh by which the land is thoroughly washed and large amounts of sediments are carried away, not allowing them to serve as a sink for heavy metals."* This might be the reason why we also found lower levels of mercury in hair of volunteers from selected sites in Bangladesh in comparison with some other countries (e. g. Thailand, Russia or Cook Islands).

Conclusions and recommendations

Levels of mercury in fish and hair of volunteers in this report are lower than in some other countries studied by IPEN, e. g. Thailand (EARTH, Arnika Association et al. 2013) or Russia (Information Center Volgograd Eco-Press, Eco-Accord et al. 2013), however some levels of mercury in both fish and hair samples raise concerns about potentially increasing levels of mercury at industrialized hot spots in Munshiganj district and near Hazaribag waste landfill. Results of this study are limited due to size of barramundi perch samples (most likely only juvenile or nearly after juvenile age) and total number of hair samples. We suggest that more fish samples of non-migratory species should be analyzed at selected hot-spots and also hair of larger group of volunteers settled at selected sites will be also analyzed, especially those whose major diet is fish. For better opportunity to compare obtained data we also suggest to express published results of Hg analyses in fish per both wet weight as well as dry weight.

Holsbeek, Das et al. (1996) concluded that *"Low hair concentrations in the Bangladeshi population, linked to the very low concentration in the consumed fish, can be partially explained by the absence of mining activities or heavy industry in the region."* It was situation in 90-ies, but as it was demonstrated on example of Gazaria upazila, Munshiganj district in this study this is not reality in Bangladesh anymore. Industry in Bangladesh has grown and there is also some indication in this study that maximum levels of mercury in both human hair and some fish species might increase as well. Further research is needed to get more complete picture. Best tool for that might be kind of National Implementation Plan on Mercury, however it is only voluntary now according proposed text of the new mercury treaty (UNEP (DTIE) 2013).

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