Draft Report of the Research

Impact of Oil Spillage on the Environment of Sundarbans (World Largest Mangrove Forest) in Bangladesh

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Background and Justification

The Sundarbans- the largest single tract mangrove forest has been declared Ramsar Site (Ramsar Authority), Natural World Heritage Site (by UNESCO) and Ecologically Sensitive Area (by Bangladesh Govt.) which is situated in the South-West area (21º 31′-22º 38′N and 89 º 00′- 89º 55′ E) of Bangladesh. It is intersected by a network of tidal canals, creeks and rivers. It is covered an area of 6000 km^2 of which 3956 km^2 mangrove forest lands and more than 1800 km^2 water bodies. This tidal forest is very rich with natural resources especially floral and faunal diversity like 66 species of plants, more than 200 fish species, 42 mammals, 234 birds, 51 reptiles, 8 amphibians, a lot of invertebrates etc. More than 500 thousand peoples are directly and indirectly depending on the Sundarbans for their livelihoods as well as socio-economic purposes. Around 200 thousand people go to the Sundarbans regularly to collect the resources for their livelihoods; less than 200 thousand collect the resources seasonally and around 100 thousand people are doing business of the collected resources and they never go to the Sundarbans directly for resources extraction. Roughly 22% people's livelihoods are involved with the collection of wood resources; 5% are involved with the non-timber forest product; 69% are involved with the aquatic resources and 4% are involved with other purposes. The plant populations of the ecologically sensitive forest- Sundarbans area are being changed due to some environmental threats like macro and micro climatic change, increasing of salinity in soil and water, natural calamity, land erosion, siltation of the river beds, decreasing of up streams fresh water flows etc. (Chowdhury 2011).

Last few years, many cargos and inland water vessels used a river channel named 'Shela river' inside the eastern part of the Sundarbans for transporting the all kinds of goods including oil from South-western area to other part of Bangladesh. According to Mongla port authority and other officials it is an unauthorized channel which was launched due to siltation of the Mongla-Ghasiakhali- Morelgonj river channel. Everyday more or less two hundred different size inland

water vessels were plying from Mongla port and South-western part to other areas of Bangladesh and were creating different types of hazards for the Sundarbans like sound and lighting pollution, dumping waste and burned oils etc. in different scales. This 'Shela river' had been declared as a sanctuary of the threatened Ganges river dolphins (*Platanista gangetica*) and Irrawaddy dolphins (*Orcaella brevirostris*) by the Govt. of Bangladesh. The branches, creeks, canals, char islands and intertidal zones of the Shela river were rich with crocodiles; used as a natural spawning ground of economically important mangrove fishes; habitats of local and migratory birds, crabs, mud skippers and others animals. Honorable Prime Minister of Bangladesh earlier said to stop the river transportation route of the Shela river but unfortunately it was not stopped. On 9th December 2014, a tanker slammed into another vessel along the Shela river. The tanker sank, spilling an estimated 75,000 gallons (350,000 liters) of fuel oil (Black furnace oil) into waterways. In the past few days, the oil has spread to cover more areas of the fragile ecosystem - including staining the Passur River - according to the authority of the Sundarbans forest department. Due to tidal systems oil reached small creeks, canals and forest floors. Thick black furnace oil deposited on the soil of intertidal zones, forests floors, plants leaves, stems, floating fruits, roots and pneumatophores (breathing roots of mangrove plants) etc. Most of the surfaces of the rivers, creeks and canals of the South-eastern part of Sundarbans were covered by the thick oil spills.

Under the circumstances, it has become imperative to institute an investigation on the estimation of oil spill hazards and their impacts on the floral and faunal communities, soil, water and ecosystems of the Sundarbans. The present study deals on the possible impact of oil spill on the ecological and biological conditions of the Sudarbans.

Materials and Methods

A research team with Environment Specialist has done the proposed research from **11 December 2014 to 25 December 2014 in 15 different locations of the oil contaminated areas of Sundarbans** (North side 22º 22' 15.47" N 89º 39' 23.78" E;. West side 22º 17' 35.66" N 89º 31' 14.27" E South side 22º 00' 40.38" N 89º 44' 38.75" E; East side 22º 07' 52.91" N 89º 49' 09.75" E). Total study area was more than 1200 square kilometer. Samples were also collected from the **3 different locations of without oil contaminated areas (Gharilal, Jorshing, Kalagachia) of the West Sundarbans**. The investigation tools used were site observations, spot and laboratory analyses, Key Informants Interview (KII), Focus Group Discussions (FGD). Besides the primary information from the field investigations, secondary information were also collected and analyzed. With the support of existing environmental condition and proposed interventions, potential environmental impacts were indentified and predicted by using standard tools and methodologies.

48 hours interval sampling (Samples were collected on 11, 13, 15, 17, 19, 21, 23 and 25 December 2014) was carried out and water, soil and biological samples were studied in the field and laboratory.

The samples of the study were collected by using a country boat. Water from 10-25 cm depth was collected for physicochemical analyses (Trivedy 1993). A standard Secchi disc was used to measure the transparency of water while for water temperature a digital thermometer was used (Model No. 950). In situ measurements of total suspended solids (TSS), total dissolved solids (TDS), conductivity, salinity, pH and dissolved oxygen (DO) were carried out with the help of respective portable field meters. Productivity was measured by following Dark-Light bottle method (Welch 1948). Titrimetric methods were used to determine free CO_2, CO_3 and HCO_3 alkalinities (Welch 1948). BOD_5, COD, NO_3.N and other chemical parameters were measured following APHA (1989). Calcium and magnesium were estimated following Mishra *et al*. (1992). Phosphate and silicate were measured following Gautam (1990). Primary productivity was measured by using dark-light bottle procedure (APHA 1989). Oil contents of water and soil were measured by sulphuric acid, Petroleum ether and separating funnel procedure (APHA 1989 & Mishra *et al*. 1992) Shovels and large ladders were used to collect the soil samples according to Trivedy (1993). Bottom soil quality was determined in the laboratory by following Jackson (1973) and Page *et al*. (1982). Plankton population was collected by using No. 20 silk bolting cloth (mesh size 0.076mm) and after collecting the plankton materials were transferred into the glass bottle and preserved permanently in Transeau's solution (Transeau, 1951). Plankton abundance was counted by using Sedge-Wick Rafter Counting Chamber (Welch 1948, APHA 1989) and expressed in unit/l whether it is an individual or a cell or a filament or part thereof. Plankton was identified by the help of relevant literatures (Edmondson 1966 & Tonapi 1980). Benthic Macroinvertebrate Samples were collected and studied by following methods of SWAMP (2007) and APHA (1989). The populations of aquatic and terrestrial plants in field were measured by following quadrate method (Ambasht 1974). Standard observations and monitoring methods (Foot/Pug marks per quadrate area/ a standard area curve) were followed for different faunal study. Latitude and longitude were measured by using a hand GPS meter.

Results and Discussion

The physico-chemical conditions of water and soil of the oil contaminated area the Sundrabans were studied and data are presented in tables. The biological components of the study area has also been studied which are presented in the following pages.

Table 1. physico-chemical conditions of water of the oil contaminated and other areas of the Sundarbans.

Parameter	Units	Oil Contaminated areas		Without Contamination area		Previous study Before Contamination	
		Range	Mean Value	Range	Mean Value	Range	Mean Value
Air temp.	°C	19.4-25	22.1±1.8	19.6-26	22.2±1.8	19.5-26	21.9±1.8
Water temp.	°C	20.1-23.5	22±0.5	22.2-26.6	24.8±0.8	22.1-26.5	24.9±0.7
****Transparency**	**cm**	**09-17**	**12±2**	19-33	26±5	23-39	27±5
****TSS** Total Suspended Solids	**mg/l**	**317-1681**	**999±447**	8.9-15.8	9.5±1.8	8.8-15.6	9.2±1.4
TDS Total dissolved Solids	g/l	17-25 g/l	21±1.3 g/l	10.8-23 g/l	16±5 g/l	10.5-23 g/l	17±6 g/l
Salinity	ppt	12.7-14.3	12.9±1.5	12.8-14.5	13±1.1	10.1-13.9	12.8±1.5
****Oil-content**	**mg/l**	**295-1650**	**995±429**	6.68-11.3	8.4±0.9	6.19-10.6	7.26±0.4
pH		7.4- 7.7	7.4±0.2	7.8-8.8	8.0±0.5	7.8-8.9	8.1±0.5
DO	mg/l	4.1- 6.1	5.4±0.3	6.3-8.0	6.5±0.8	6.3-7.9	6.7±0.8
****Productivity**	**mg/l**	**1.7-3.1**	**2.4±0.3**	**12.5-16.9**	**14±0.5**	**16.6-19**	**17±0.8**
BOD_5	mg/l	2.5-3.9	2.8±0.5	1.4-2.4	1.9±0.3	1.3-2.3	1.7±0.3
COD	mg/l	**275-598**	**377±104**	56-81	69±8	51-74	63±5
CO_2	mg/l	16-36	25±6	-	-	-	-
CO_3 alk.	mg/l	-	-	24-39	29±10	16-38	28±7
HCO_3 alk.	mg/l	115-157	131±23	97-132	112±16	81-117	93±11
**** Total Hardness**	**mg/l**	**1974-2232**	**2156±132**	940-1185	965±41	912-1128	946±53
Ca^{2+}	mg/l	746-861	769±72	492-684	575±51	465-676	556±47
Mg^{2+}	mg/l	477-585	489±63	230-426	315±75	221-410	307±59
PO_4	mg/l	1.84-2.08	1.93±0.09	1.69-1.81	1.72±0.07	1.66-1.79	1.71±0.05
Silicate	mg/l	4.96-6.97	5.71±0.56	5.04-6.89	5.63±0.77	4.78-6.84	5.42±0.43
NO_3.N	mg/l	2.79-4.26	3.42±0.60	2.34-3.64	2.80±0.48	2.26-3.52	2.74±0.40
****Phytoplankton**	units/l	**24 - 67**	**32±19**	**171 -349**	**324±65**	**226 - 456**	**407±53**
****Zooplankton**	units/l	**6 - 10**	**7±1.5**	**45 -71**	**52±13**	**53 - 77**	**59±14**

**** = Indicates the high contamination by the Oil pollution;** - = Not detected

Table 2. Chemical Properties of the Soils of the oil contaminated and other areas of the Sundarbans.

Parameter	Units	Oil Contaminated areas		Without Contamination area		Previous study Before Contamination	
		Range	Mean Value	Range	Mean Value	Range	Mean Value
pH		7.6-7.9	7.7±0.1	7.8-8.4	8.0±0.2	7.8-8.5	8.1±0.2
Salinity	ppt	12.2-14.1	13.2±0.7	12.3-14.5	13.4±0.4	9.7-14.7	11.8±1.1
**** Oil-content**	**mg/ kg of 2 inch surface soil**	**370-1690**	**1080±420**	**4-8**	**5.5±0.6**	**2-4**	**3 ±0.2**
Calcium	meq/ 100g soil	13.5-15.5	14.2±1.1	13.6-15.9	15±0.6	11-24.3	17.5±5.4

Magnesium	meq/ 100g soil	10-10.9	10.3±0.3	10.4-12.7	11.5±1.6	10-11.8	10.8±0.3
Potassium	meq/ 100g soil	1.45-1.69	1.53±0.10	1.45-1.98	1.62±0.39	1.39-1.71	1.56±0.07
Total Nitrogen	%	0.21-0.28	0.24±0.019	0.14-0.19	0.17±0.006	0.13-0.14	0.13±0.01
Phosphorus	µg/g soil	72-285	179±91	15-19	16±0.9	13-17	14.7±2.1
Sulfur	µg/g soil	98-115	104±9	85-105	94±4	69-201	168±25

** = Indicates the high contamination by the Oil

During the periods of study high Oil content, TSS, Chemical Oxygen Demand (COD) and total hardness; low transparency, poor productivity, poor diversity and abundance of phytoplankton and zooplankton, and high content of oil in soil indicate that the water and soil of the study areas of the Sundarbans have become polluted by the oil contamination.

Internationally highest 10 mg /l oil contamination is tolerance level of aquatic biodiversity. More than 10 mg/l of oil creates lethal conditions for the aquatic lives. Chowdhury & Zaman (2001) and Bhuayan (1983) also reported in Bangladesh that oil contamination is responsible for high TSS, COD, hardness etc. and low transparency, lower rate of productivity and poor plankton populations.

Table 3. Phytoplankton (Primary Producer of the food chain of aquatic environment) status of the oil contaminated and other areas of the Sundarbans.

Phytoplankton	Oil Contaminated areas	Without Oil Contamination area	Previous study Before Contamination	Comments
	abundance (units/l)	abundance (units/l)	abundance (units/l)	
Class: Cyanophyceae				Primary producer of the Sundarbans river systems. ***But after oil spilling their diversity / Types and abundance have been decreased as remarkable number
Calothrix castellii	-	1-4	3-7	
Calothrix fusca	-	5-10	6-12	
Lyngbya corticicola	-	2-4	5-9	
Lyngbya confervoides	-	3-5	4-10	
Lyngbya lutea	0-1	2-6	5-10	
Oscillatoria amoena	-	7-12	8-14	
Oscillatoria limosa	3-4	3-6	5-8	
Oscillatoria princes	-	1-3	3-5	
Oscillatoria subbrevis	-	7-11	7-14	
Oscillatoria tenuis	2-5	9-15	11-17	
Schizothrix lamyi	-	1-3	2-4	
Spirulina major	2-4	6-10	6-11	
Spirulina subsalsa	-	3-4	7-10	
Microcoleus chthonoplastes	-	2-5	3-7	
Class: Chlorophyceae				
Chlorella vulgaris	2-4	4-9	5-8	
Closterium costatum	-	6-12	7-14	
Closterium lagoense	-	8-14	9-18	
Class: Bacillariophyceae				

Phytoplankton	Oil Contaminated areas	Without Oil Contamination area	Previous study Before Contamination	Comments
	abundance (units/l)	abundance (units/l)	abundance (units/l)	
Chaetoceros pendulus	-	10-16	11-20	
Chaetoceros socialis	-	6-15	7-22	
Coscinodiscus excentricus	-	8-12	9-15	
Coscinodiscus granii	-	9-13	10-16	
Coscinodiscus lineatus	-	3-9	6-14	
Coscinodiscus marginatus	1-2	1-6	3-8	
Coscinodiscus stellaris	-	2-8	4-10	
Coscinodiscus tumidus	-	3-7	4-9	
Cyclotella bodanica	-	1-7	3-8	
Cymbella gracilis	-	2-6	4-8	
Gyrsigma distortum	1-2	2-4	3-7	
Melosira arenaria	-	8-13	9 -16	
Melosira granulate	1-2	5-11	7-13	
Melosira varians	-	2-5	2-6	
Melosira moniliformis	1-3	3-8	3-10	
Melosira sol	-	2-3	3-5	
Melosira undulate	1-4	5-12	6-14	
Navicula bacillum	1-2	2-4	3-6	
Navicula brekkaensis	-	3-6	4-9	
Navicula grimmei	0-1	1-3	3-6	
Nitzschia acicularis	-	2-5	3-6	
Nitzschia sigma	2-3	4-7	4-8	
Surirella fastuosa	-	2-5	4-7	
Surirella robusta	1-3	7-10	7-14	
Synedra ulna	-	2-8	3-10	
Class: Euglenophyceae				****Presence in oil contaminated areas Indicate the Pollution**
***Euglenea* sp. *(2 sps.)*	4-10	-	-	
Phacus sp.	1-2	-	-	
Class: Xanthophyceae				
Centritractus belanophorus	-	3-6	4-8	
Class: Dinophyceae				
Ceratium dens	0-2	1-2	1-3	
Ceratium extensum	1-2	1-5	-	
Total	**24 – 67**	**171-349**	**226- 456**	

'-' Not detected

Only 18 Phytoplankton (Primary producer of food chain) species were recorded in the oil contaminated areas and abundance was very poor (24-67 units/l) but earlier 47 Phytoplankton species were recorded in the Sundarbans and abundance was 226 – 456 units/l. The results indicate that phytoplankton diversity and population/ abundance were affected by the oil contamination. Presence of *Euglena* sp. and *Phacus* sp. (pollution indicator) in oil contaminated areas also supported in the findings. Poor productivity of the oil contaminated areas also supported this finding.

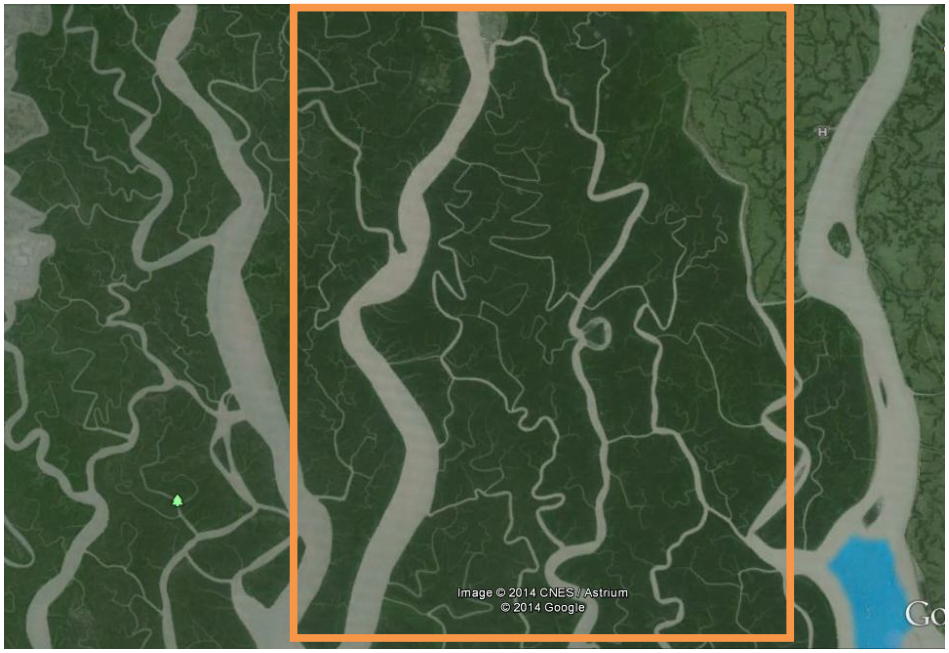

Figure 1: Study area.

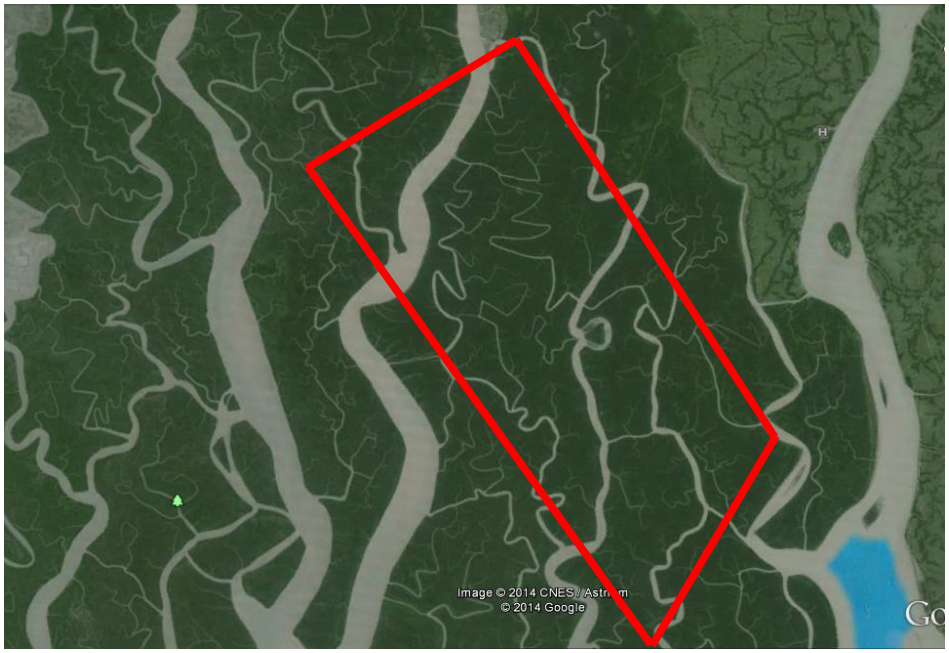

Figure 2: More contaminated area.

Table 4. Zooplankton (Primary Consumer of the food chain of aquatic environment) status of the oil contaminated and other areas of the Sundarbans.

Zooplankton Abundance	Oil Contaminated areas	Without Oil Contamination area	Previous study Before Contamination	Comments
	abundance (units/l)	abundance (units/l)	abundance (units/l)	
Protozoa				
Favella taraikaensis	3-5	-	-	**Presence of Protozoa Indicates the oil pollution**
Cladocera				
Evadne tergestina	-	2-5	4-6	
Copepoda				
Calanus helgolandicus	-	6- 8	7-9	
Calanopia thompsoni	-	6-10	8-11	
Corycaeus flaccus	-	7- 13	9-12	
Lucifer typus	-	8- 11	7-11	
Microsetella rosea	2-3	6-9	7-10	
Oithona rigida	1-2	8-12	9-14	
Oncaea venusta	-	2-3	2-4	
Total	**6 - 10**	**45 -71**	**53 - 77**	**Due to oil pollution only two types zooplankton are present**

'-' Not detected

Only 2 zooplankton (Primary consumer of food chain) species were recorded in the oil contaminated areas and abundance was very poor (6-10 units/l) but earlier 8 zooplankton species were recorded in the Sundarbans and abundance was 53 – 77 units/l. The results indicate that zooplankton diversity and population/ abundance were affected by the oil contamination. Presence of Protozoa (pollution indicator) in oil contaminated areas also supported in the findings.

Table 5. Benthos (Playing vital role in the food chain of the aquatic environment) status of the oil contaminated and other areas of the Sundarbans.

Benthos	Oil Contaminated areas	Without Oil Contamination area	Previous study Before Contamination	Comments
	(In per square meter of Inter tidal zone)	(In per square meter of Inter tidal zone)	(In per square meter of Inter tidal zone)	
Order: Coleoptera				
Dubiraphia vittata	-	++	++	
Promoresia tardella	-	+	++	
Order: Crustacea				
Gammarus fasciatus	+	+++	+++	
Palaemonetes paludosus	-	++	++	
Order: Diptera				
Ablabesmyia mallochi	+	+++	+++	
Cricotopus vierriensis	+	++	+++	
Cryptochironomus fulvus	-	++	+++	

Benthos	Oil Contaminated areas (In per square meter of Inter tidal zone)	Without Oil Contamination area (In per square meter of Inter tidal zone)	Previous study Before Contamination (In per square meter of Inter tidal zone)	Comments
Microtendipes pedellus	-	-	++	
Orthocladius dorenus	-	++	++	
Tribelos jucundum	-	-	++	
Order: Ephemeroptera				
Acentrella Alachua	-	-	++	
Baetis Pluto	+	+	++	
Drunella lata	-	+	++	
Iswaeon anoka	+	++	+++	
Order: Gastropoda				
Cerithidea cingulata	-	++	++	
Helisoma anceps	-	+	++	
Laevapex fuscus	-	++	+++	
Micromenetus dilatatus	-	++	+++	
Plicarcularia leptospera	-	++	++	
Valvata cristata	-	++	+++	
Order: Hemiptera				
Belostoma sp.	-	+++	+++	
Order: Megaloptera				
Corydalus cornutus	-	++	++	
Order: Odonata				
Boyeria grafiana	+	++	++	
Epicordulia princeps	-	+++	+++	
Order: Oligochaeta				
Limnodrilus hoffmeisteri	-	+++	+++	
Limnodrilus profundicola	-	+	+++	
Tubifex heterochaetus	-	++	++	
Tubifex tubifex	-	+++	+++	
Order: Bivalvia				
Corbicula fluminea	-	++	+++	
Elliptio complanata	-	++	++	
Order: Plecoptera				
Eccoptura xanthenes	-	++	++	
Haploperla brevis	-	-	++	
Order: Trichoptera				
Micrasema bennetti	+	+	+++	
Molanna blenda	-	++	++	
Total nos. of present species	**7**	30	34	

'+ + +' Very Common; '+ +' Common; '+' Rare; '-' Not detected

Only 7 Benthos (Playing vital role in the food chain of the aquatic environment) species were recorded in the oil contaminated areas and abundance was poor (rare) but earlier 34 benthos species were recorded in the Sundarbans and abundance was common. This result indicates that benthos diversity and population/abundance were affected by the oil contamination.

Table 6. Floral and Faunal status of the oil contaminated and other areas of the Sundarbans.

Name of the flora and Fauna	units	Oil Contaminated areas	Without Oil Contamination area	Previous study Before Contamination	Comments
Seedlings of Plants on intertidal zones	no./m^2	2-3 Most of the seedlings have been covered by black oil and going to be decomposed.	9-12	12-18	
Saline water lily on intertidal zones	no./m^2	- Plants body is being decomposed due to oil spills.	10-14	12-22	
Fruits/Seeds of Sundari Plants	no./m^2	9-14 95% seeds have been covered by black oil.	10-18	10-19	Embryo of oil coated seeds have been decomposed as a result seed will not be germinated
Pneumatophores (Breathing roots) of plants	no./m^2	>90% Pneumatophores have been covered by black oil.	-	-	Physiological activities of these plants have become affected by the oil spills
***Catenella* sp. (3sps.)-** a red algae attached with plant roots	no./m^2	>95% have been decomposed due to oil spills.	Present in good conditions	Present in good conditions	Worked as primary producer; Source of food and nutrient of the many aquatic animals
***Colpomenia* sp. (2sps.)-** a brown macro algae grows in small creeks as benthic form	no./m^2	All have been decomposed due to oil spills.	Present in good conditions	Present in good conditions	Worked as primary producer; Source of food and nutrient of the many aquatic animals
Eggs & hatchlings of different fishes i.e. Parse, Khursula, Bagda, Harina etc.	units/l	- Totally absent **(But this is the breeding season of these fishes)**	1500 to 2000	2100 to 2400	Source of natural and cultivated fish production in the Sundarbans and South-west coastal areas of Bangladesh
Mudskippers – a common intertidal zone fish	no./m^2	- Totally absent	2-4	3-7	Indicator of mangrove ecosystem and Use as food by the birds, fishing cat, otter, snake and other animals.
Mud Crabs (Kakra) (4sps.) – a common intertidal zone Crustacea	no./m^2	- Totally absent **(Found dead and decomposed bodies)**	2-4	3-7	Indicator of mangrove ecosystem and Use as food by the birds, Crocodiles and other animals.
Snails (Shamuk) (10 sps.) – a common intertidal	no./m^2	- Totally absent **(Found dead and**	8-14	9-17	Indicator of mangrove ecosystem and Use as food by the

Name of the flora and Fauna	units	Oil Contaminated areas	Without Oil Contamination area	Previous study Before Contamination	Comments
zone Mollusk		**decomposed bodies)**			Fishes, birds, Crocodiles and other animals.
Fishes –common fishes of the Shela river, canals, creeks etc.	No of species	**10-14 species**	27-33 species	31 - 43 species	Major aquatic resource of the Sundarbans and Use as food by the birds, fishing cat, otter, snake, dolphins, crocodiles and other animals.
Frog (2sps.) – intertidal zone of the Shela river & canals are the habitats	Study period	Six dead and five black oil covered Frog were observed in the study period	Many Frog were observed in the intertidal zones	Unlimited Frog were observed in the study area	Common Amphibian of the Sundarbans
Snakes	Study period	4 dead snakes were observed in the study period	Two Snakes were observed due to winter season	Different types Snakes were observed in the Sundarbans	Vey Common Reptile of the Sundarbans
Monitor Lizards (3 sps.) – intertidal zone of the Shela river & canals are the habitats	Study period	One dead and two black oil covered monitor lizards were observed in the study period	16 Monitor Lizards of 3 different species were observed	21- 27 Monitor lizards of 3 different species were observed in the study area	Common reptiles of the Sundarbans
Crocodile – common animal of the Shela river and connected canals	Per day/ study period	Only oil coated two crocodiles were observed in the study period	2-4 crocodiles were observed in a day	3-6 crocodiles were observed in a day	Threatened species and Indicator of the mangrove ecosystem
Intertidal Bird (Masked finfoot) – intertidal zone of the Shela river & canals are habitat	Study period	No **Masked finfoot** bird was observed in the study period	No **Masked finfoot** was observed	21 **Masked finfoot** birds were observed in the study area	Worldwide Threatened species and only the mangrove bird
Common Birds – common animal of the Shela river and connected canals	Study period	Only oil affected 17 birds **(Heron)** were observed in the study period	34 types Birds were observed	56 types Birds were observed	Threatened species and Indicator of the mangrove ecosystem
Ban Morog (Birds) – common beside the Shela river and connected canals	Study period	No **Ban Morog** was observed in the study period	7 **Ban Morog** were observed	**Ban Morog** was available	Common bird of the mangrove ecosystem
Migratory Birds – intertidal zone of the Shela river & canals are habitats	Study period	No **Migratory** bird was observed in the study period	Few migratory birds was observed	Many **Migratory** birds were observed in the study area	The Sundarbans is the habitat of the Migratory birds, It is the time of migratory birds
Fishing cat	Study period	Only one dead Fishing cat was observed in the study period	Foot mark of fishing cat were observed in the intertidal zones	Many foot mark of fishing cat were observed in the study area	Common animal of the Sundarbans
Otter – intertidal zone of the Shela	Study period	2 dead and 1 black oil covered **Otter**	Foot/ Pug Marks of Otter were	Unlimited Foot Marks of Otter	Threatened animal in the main land but a Common

Name of the flora and Fauna	units	Oil Contaminated areas	Without Oil Contamination area	Previous study Before Contamination	Comments
river & canals are the habitats		were observed in the study period	observed in the intertidal zones	were observed in the study area	Animal of the Sundarbans
Dolphins – common animal of the Shela river and connected canals	no./hour	No dolphin observed in the oil contaminated areas	5-10 times movements were observed in a hour	7-12 times movements were observed in a hour	Threatened species and Indicator of the mangrove ecosystem
Deer – beside the Shela river & connected canals	Study period	No deer was observed in the study period	Deer was Available in the study area	Unlimited deer were observed in the study area	Common Animal of the Sundarbans
Wild Boar – beside the Shela river & connected canals	Study period	No **Wild Boar** was observed in the study period	Wild Boar were observed in the study area	Unlimited Wild Boar were observed	A Common Animal of the Sundarbans

'-' Not detected

On the basis of present conditions of the study areas like physico-chemical conditions of water and soil; floral and faunal status it can be concluded that the intertidal zones and the forest floor besides the river Shela and connected canals, creeks of the Sundarbans have been contaminated by the furnace oil, earlier this areas were free from this type of oil pollution. Floral and faunal statuses are indicating that primary producer, consumer and some aquatic animals and some plants and their habitats have already been affected by the oil pollution. Due to oil contamination besides the river, canals and creeks Crocodiles could not prepare their hatchling house in these areas to lay and hatch their eggs. It is a natural habit of crocodile to prepare their hatchling house besides the rivers, canals and creeks during the month of April- May. But before heavy rainy season (July - August) there is no possibility to reduce the oil pollution in the crocodile hatchling habitats. As a result crocodile may migrate from their own habitats and face territory conflict and ultimately crocodile's population will be affected.

More than 500 km^2 areas out of the total study area (more than 1200 km^2) have been affected seriously by the oil spills contamination.

******Regeneration of the Sundari trees; population, habit and habitats of Mudskippers, Mud Crabs (Kakra), Snails (Shamuk), Monitor Lizards (Guishap), Intertidal zone Birds (world endangered bird 'Masked finfoot'), Common Birds (Bok, Machranga etc.), fishing cat, otter (Bhondor), dolphins and crocodile will be affected** due to contamination of the oil spills hazards on 9th December 2014.

It is a matter to be concerned when the Sundarbans reserve forest is already facing threats from natural calamity, deforestation, rise in salinity and extinction of many species mainly due to

human carelessness, ignorance and lack of implementation of laws, poaching and illegal wildlife trade etc.

Impact (Summery/ Conclusion) of oil spills pollution on the Sundarbans are as follows:

1. Food chain/ food web of the aquatic lives have been broken.
2. Physiological activities and breeding systems of all Aquatic lives i.e. plants, all vertebrates and invertebrates (oxygen and food producing phytoplankton and other microorganisms, zooplanktons, insects, all fishes, shrimp, crabs, mudskipper, otter, fishing cat, dolphins, crocodiles, turtles, aquatic birds etc.) will be affected due to lost /changed habitats. As a result above mentioned aquatic lives will be died out or will be migrated.
3. Population of the aquatic lives will be decreased and long time impact on aquatic lives like loss of breeding capacity, habitat loss, injury of respiratory organs, hearts and skins will be happened.
4. Already some fishes, crabs, mudskipper have died out and floated in small creeks and canals.
5. This is the breeding season (last week of November to first week of January) of some Sundarbans associated commercially valuable fishes like Parshe (*Liza* spp.), Khorsula (*Mugli* spp.), Bagda shrimp (*Penaeus monodon)* etc. The eggs, larva and fingerlings size fry of these fishes can't survive due to oil spills pollution. Intertidal zone and shallow creeks, canals and rivers sides are the ideal places of the eggs, larva and fish fry but these areas have been polluted by the thick oil layer. People collect the above mentioned natural fish and shrimp fry from the rivers, creeks and canals for their commercial cultivation in the fish culture water bodies in the South-West coastal areas of Bangladesh. Parshe and Khorsula fry can't possible to grow in the hatchery. The Sundarbans is the only source of these fish fry.
6. So a lot of people livelihoods will be affected who are related with above mentioned fishes as a fish and shrimp fry collectors, cultivars, sellers, labor of fish processing industries, fish processor and exporter etc.
7. This is the time of migratory birds, which will not come in the Sundarbans due loss of habitats and food chain by the oil spills.
8. Only 200- 250 nos. of one internationally endangered mangrove bird (name 'Masked finfoot- *Heliopais personata*') is present in the oil affected area. These birds collect their foods from the intertidal zones of creeks and canals. This bird may be affected by the oil spills.
9. The Sundarbans is the spawning ground of shrimp, most of the saline water fishes, crabs, otter, dolphins, crocodiles etc. Due to oil spill this spawning ground has been affected.
10. Pneumatophores (Breathing roots - special rooting systems of the mangroves plants) of the different woody plants including Sundari (*Heritiera fomes* – a major tree species of the forest), Keora (*Sonneratia apetata* – leaf is the main food of the spotted dear), Gewa (*Excoecaria agallocha*), etc.; Khalisha (*Aegiceras corniculatum* – flower is the prime source of Honey), Golpata (*Nypa fruticans* – leaf collection is one of the major

livelihood of the people), Tiger fern (*Acrostichum aurium* - ideal den of tiger) etc. have been covered by the oil. As a result growth of seedlings and physiological activities of these plants have become affected by the oil spills. Seedlings and some other plants will be died out. Soil of the forest floor will absorb this polluted oil, and microorganisms of the soil and rooting systems of the plants will be affected by decompose.

11. Some impacts will be continued in the long time as the natural degradation of this type of oil is very slow. Next six- seven months (before June-July 2015) there is no possibility of rainfall. So there is no possibility of natural washing of the oil within short time.
12. Crocodile can't hatch the eggs during the coming months April- May.

How to clean the oil?

The Sundarbans (Mangroves forest) are the most sensitive shore- line habitat to oil spill effects. They are slow growing, sensitive to oil, and difficult to clean. They usually grow in low energy environments where oil can persist for years. These areas should receive the highest protection priority during a spill. Every effort should be made to minimize the amount of oil that is allowed to enter a mangrove area, without causing greater harm.

Some cleaning processes are as follows:

Booming: Booms are often deployed to protect the most sheltered areas, where the greatest persistence is likely. Booms should be placed at an angle to the current, and divert the oil to a location where collection is possible. Booms should be placed so as not to contact the bottom or the mangrove roots. Sorbents placed along the mangrove fringe may reduce the quantity of stranded oil. Sorbents can also be used to collect sheens coming from oil that has already stranded. Snare booms are more effective in collecting heavier oils. Sorbents must be changed periodically as they become saturated with oil. Sorbents may also be used to wipe heavy accumulations of oil from prop roots in areas of firm substrate.

Skimmers: These are usually propylene mop-like pads that are placed on the water surface to absorb the spilled oil film.

Natural and synthetic sorbent materials: The use of sorbent materials is a very common method of controlling a large variety of spills including oil spills. The general principle relies on using materials with a sponge-like behavior. These materials have the ability of removing some of the spilled oil as well as serving as physical barrier limiting oil migration.

Oiled Debris Removal: Mangrove environments often have a wrack line along the high tide and storm lines. If this wrack becomes oiled it can be a source of chronic sheening and should be removed. Care must be taken not to disturb the substrate. Vegetation should never be cut or removed.

Vacuums: It can be used to remove oil from intertidal zones and water surface.

Shovels and other road equipment: These typically used to clean up oil from intertidal zones.

Bioremediation: Use of microorganisms or biological agents to break down or remove oil; such as the bacteria *Alcanivorax* or *Methylocella silvestris.* These specific bacteria break down the hydrocarbons into water and carbon dioxide.

Natural Recovery: When cleanup activity causes more environmental damage than the oil, natural recovery should be considered. Natural recovery should also be considered when heavy products are located deep in the mangrove forest or when removal causes mixing with sediments. The placement of sorbents is often used to recover sheens released during natural removal. Any cleanup activity that disturbs nesting birds should be postponed until the young have fledged.

What should be done for future?

The following recommendations should be followed as soon as possible to protect the Sundarbans from further degradation by this type of hazard:

1. Immediately all kinds of fuel (Coal, oil etc.) and fly ash containing ships or vessels movement must be prohibited inside the Sundarbans.
2. Alternative river transportation routes must be launched from Mongla port to other parts of the country as soon as possible.
3. The rules and regulations of international conventions like Ramsar, UNESCO Natural Heritage Site, Convention of Biological Diversity etc. must be implemented properly.
4. A national commitment is necessary to stop all kinds of activities which may create the problem for the fragile ecosystem of the Sundarbans.

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