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ASSESSEMENT OF GHG EMISSIONS FROM SARDAR-SAROVERRESERVOIR IN INDIA USING GHG RISK ASSESSMENT TOOL

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Abstract:

Climate change and the occurrence of extreme weather conditions are the major concepts which are linked to global warming. So far hydro power has been considered as the clean source of energy by recent studies has proven that the creation of a dam along a water body will result in the greenhouse gases (GHGs) emission which is responsible for global warming. The OM originates from the flooded area, acts as the primary production in the reservoir which flows from upstream to downstream part of the reservoir. The multiple pathways in which the gases reach the atmosphere are in diffusing flux, bubbling, flux through macrophytes and in the upstream and downstream of the reservoir itself. A large amount of gases is also released into the atmosphere when the water is passing the turbine and the spillway. When globally compared some reservoirs emission are very high when compared with thermo-power plants. In this paper past 16 years data of seven hydro power stations which are located in India at different climatic zones has been analyzed. A mean annual daily temp from past 16years (1997-2012) has been analyzed for seven hydro power stations in India Similarly for rainfall, mean annual rainfall over 16 years being obtained. And finally by using UNESCO/IHA GHG Risk Assessment Tool (Beta Version) predicted diffusive fluxes in CO_2*eq has been calculated for that particular year and predicted values over hundred years for the selected hydro power stations are also obtained using the same tool.*

1. INTRODUCTION

In this chapter a model has been designed and used for estimating the minimum and maximum limits of GHG emissions from a reservoir by studying the various components/ parts of the water reservoir in a hydro power scheme. The multiple pathways in which the gases reach the atmosphere are by diffusing flux, bubbling, flux through macrophytes and in the river downstream of reservoir itself. A large amount of gases are also released into the atmosphere when the water is passing through the turbine and the spillway. The organic matter(OM) which is present in terrestrial ecosystem (biosphere and lithosphere) will get transported to water bodies like rivers, lakes and water flow by surface and sub-surface flow. The OM originated from the flooded area, acts as the primary production in the reservoir which flows from upstream to downstream part of the reservoir. Further, storage based hydropower projects which are located in the tropics represent an important anthropogenic GHGs source. This chapter describe the model used for estimating the GHGs emission from a reservoir as suggested by UNESCO/IHA GHG Research Project (2009). This model uses the secondary data available in literature for estimating the ranges for GHGs emissions. The methodology has been explained with the help of a real time case study of a hydropower project from India.

PATHWAYS OF GHG EMISSIONS FROM RESERVOIR

On creation of a reservoir, emission from different parts of the reservoir will takes place. Figure 1 shows detail sources of GHGs emission from the reservoir. As per water bodies emission the main GHGs which are calculated are CO_2 and CH_4. This both gases are released into atmosphere as diffusive flux, degassing and CH_4 is released in the form of bubbles from bottom sediment part of reservoir but at favorable conditions. The OM which present in the soil and plants is imported from the catchment in addition to that OM which preexisting in the reservoir together will decomposes in aerobic and anaerobic conditions and emits GHGs to the atmosphere with the help of some parameters (primary and secondary).

CO_2 and CH_4 emissions to the atmosphere from reservoirs include:

1. Bubble fluxes (ebullition) from the shallow part of water bodies.
2. Diffusive fluxes which are emitted from water surface of the reservoir;
3. Diffusion through macrophytes.
4. Increased diffusive fluxes along the downstream part of the reservoir

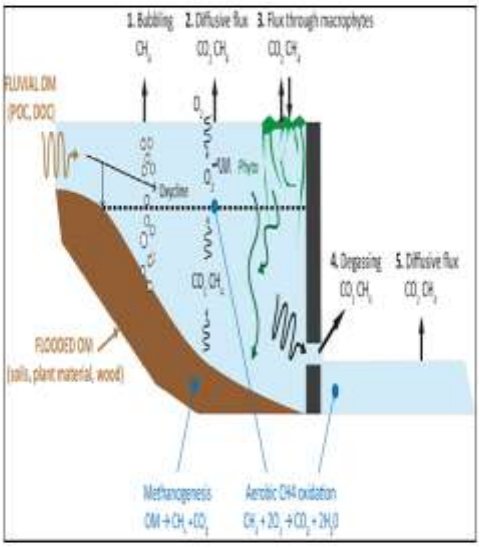

Figure 1: Pathways of GHG Emissions from a Reservoir (IPCC 2007).

From the Figure1, one can know the point sources from where the GHGs are emitted. Therefore, the total amount of GHGs emission to the atmosphere can be given by

TOTAL GHGs EMISSION CONSIDERING THE WHOLE RESERVOIR *(Te)*:

$$T_e = E_b + D_{us} + E_m + D + D_{ds}$$

E_b = Emission of CH_4 through bubbling, D_{us} = Emission of CO_2 through diffusive flux at upstream part of the reservoir, E_m = Emission of CH_4 through macrophytes, D = Emission of CO_2 through degassing, D_{ds}= Emission of CO_2 through diffusive flux at downstream part of the reservoir

Before going into details of this equation, it is desired to know about the carbon cycle and carbon transfer from terrestrial to aquatic system so as to know the probability of predicted values when compared to the experimental values of the emission.

Calculation of Diffusive Flux from Aquatic Ecosystem

1. Diffusive Flux:

At Air-water interface this both CO_2 and CH_4 will be transferred by diffusion from the aquatic ecosystems. This pathway happens at reservoir upstream and downstream and it is based on the Henry's law difference of partial pressure of a gas between the air (Pa) and the water (Pw). If Pw is higher than **Pa** the gas diffuses from the water to the atmosphere because a chemical compound always diffuses from the most concentrated layer to the less concentrated. Several parameters control the intensity of the diffusive fluxes: the gradient itself (the bigger it is, the bigger the flux is) and also some physical parameters like wind speed, water current velocity, rainfall, and temperature enhance the fluxes.

C-CO_2 Flux model formulas:

Several alternative formulations were attempted by the UNESCO/IHA greenhouse gas emissions from freshwater reservoirs research project the following general expression has been given as the best fitting expression which consider the parameters which are responsible for the emission of CO_2 from the reservoir by considering the age of reservoir.

$$Flux\ C-CO_2 = 186.0 + 0.148 \times R + \left(944.485 + 1.91 \times T + 0.09727 \times T^2\right) \times e^{-0.044 \times \left[52.339 - 0.7033 \times T - 0.0358 \times T^2\right] \times Age}$$

The above formula is the best framed after several attempts and the above depends on three main parameters they are 1) Runoff (R) 2) Temperature (T) 3) Age of the reservoir. Reason for consideration of these parameters are:

- Max CO_2 emission occurs after flooding so positive factor of temperature
- The steepness of the initial decline (the exponential term) is a negative function of temperature

C-CH_4 Flux model formulas:

The emission of CH_4 mainly depends on the precipitation over that area. In the case of CH_4 a different modelling has been considered. While the Project did test the same model structure as for CO_2, little predictive gain was obtained relative to simpler empirical modelling approaches. In the end, the Project used a semi logarithmic model combined to a regression tree approach, with different empirical models for different segments of the variable space. In particular, we developed a model where CH_4 flux is a function of mean annual temperature, mean annual precipitation and age for reservoirs that are 32 years old or less. For older reservoirs, diffusive methane emissions are constant in time at a level which is determined by temperature and precipitation only. The following models were developed:

Formula for reservoir aged **≤ 32 years**

$$C-CH_4 = 10^{\left(1.46 + 0.056 \times T - 0.00053 \times P - 0.0186 \times Age + 0.000288 \times Age^2\right)}$$

Formula for reservoir aged > 32years up to 100 years

$$C-CH_4 = 10^{\left(1.16 + 0.056 \times T - 0.00053 \times P\right)}$$

At certain age of the reservoir the emission of CH_4 depends on the temperature and precipitation only. CH_4 is a function of mean annual temperature (T), mean annual precipitation (P) and Age of the reservoir that are 32 years old or less.

Range of variability of the estimates:

The predicted value has been estimated by using the equations which have been explained in section 6.4.1. And the values of the "lower limit" and the "upper limit" can be estimated as a function of the predicted values of gross GHG fluxes (of CH_4 and CO_2) and the mean square errors. Table 1 expresses how to estimate the values of the limits of the 67% confidence interval, for the models adopted in GHG Risk Assessment Tool. The confidence interval for the predictions which is considered in the in GHG Risk Assessment Tool.

Table 1: Limits of predicted values of the 67% confidence interval

Predicted Value	Lower limit	Upper limits
Gross C-CO_2 Flux	$\frac{1}{2.3}$* "Predicted Gross C-CO_2 Flux"	2.3* "Predicted Gross C-CO_2 Flux"
Gross C-CH_4 Flux	$\frac{1}{3.55}$* * "Predicted Gross C-CH_4 Flux"	3.55* "Predicted Gross C-CH_4 Flux"

(Both models have uncertainty best described on a base-10 logarithmic scale. Consequently, the factors 2.3 and 3.55 are derived from $10^{0.36}$ *and*$10^{0.55}$*, respectively.)*

Empirical models were developed in the GHG Risk Assessment Tool to explain the variability of gross CO_2 and CH_4 diffusive fluxes. An intrinsically non-linear approach was adopted, affording flexibility in the shapes of the curve describing the initial decline of GHG emissions following flooding in this model. The model for predicting CO_2 diffusive fluxes was able to explain about 45% of the variation observed in the data used for calibration, and had an uncertainty best described on a base-10 logarithmic scale (root mean square error=0. 36). The model for predicting CH_4 diffusive fluxes was able to explain about 42% of the variation observed in the data used for calibration. Its uncertainty is best described by a logarithmic root mean square error of 0.55. The range of variability of the estimates can be expressed by the confidence interval of the predicted values. The confidence interval for the predictions is obtained as:

P ["lower limit" ≤ "GHG flux" ≤ "upper limit"] = α%

Meaning that there is α% of probability that the "GHG flux" will be in the interval between the " lower limit" and the "upper limit". The values for "lower limit" and "upper limit" of the 67% confidence interval for the predictions are taken from table6.1.

Estimation of Bubbling Flux from Reservoir

Bubbling fluxes (or ebullition) represents the direct transfer of CH_4 from the sediment to the atmosphere with a small interaction of Aerobic Methane Oxidation (AMO). By receiving large amount of OM by sedimentation, methanogens bacteria are very active and CH_4 accumulates in the sediments. Bubbles develop if CH_4 concentration in the sediment pore water exceeds its maximum solubility in water. Bubbling fluxes mainly occur in shallow part of lakes and reservoirs. At larger depths approximately 20m, the hydro static pressure is too high for bubbles to form so there only dissolved CH_4 can exists.

A CASE STUDY OF SARDAR-SAROVAR

The Sardar-Sarovar Hydro power has two power houses - River Bed Power House and Canal Head Power House with combined installed capacity of 1450 MW and benefits to be shared between Madhya Pradesh, Maharashtra and Gujarat.A GIS switch yard complex, and the 400 KV power transmission network up to MP-Gujarat and Maharashtra -Gujarat borders in Gujarat and the project area is shown in the Figure 2.

Location coordinates of Sardar-Sarovar reservoir are: Latitude= 21.826, Longitude= 73.749.It is a reservoir formed by the main dam with a gross storage capacity of 0.95 million hectare meters (7.70 MAF) and a live storage of 0.58 million hectare meters (4.73 MAF).

Figure2: Project area of Sardar – Sarovar

ESTIMATION OF COMPLETE EMISSION FROM SARDAR-SAROVAR RESERVOIR

1. Diffusive flux

The data of the Sardar-Sarovar RBPH have been collected according to the latitude and longitude basics, the mean annual daily air temperature and Mean annual precipitation from the located surface has been analyzed by collecting the data from 1997-2012 from NASA Prediction of Worldwide Energy Resource (POWER). Run-off data are obtained from UNH/GRDC composite run-off fields V 1.0. And the analyzed values are shown in Table 3

Table 2 Details of Sardar-Sarovar RBPH for Diffusive Fluxes calculation using UNESCO/IHA Risk Assessment Tool

STATION	SA Km^2	AGE	DMAP (1997-12) (mm/year)	RUNOFF (mm/year)	DMAT(^{0}C) (1997-12)	LAT	LON
Sardar Sarovar-RBPH	375.33	8	960.14	408	27^{0}C	21.82	73.98

SA – SURFACE AREA, DMAP- DAILY MEAN ANNUAL PRECIPITATION, R – RUNOFF, LAT- LATITUDE, LON – LONGITUDE, DMAT - DAILY MEAN ANNUAL TEMPERATURE

Table 3Thresholds limits for CO2 and CH4 emissions (mg C-CO$_2$ m^{-2} d^{-1})

Thresholds for comparison with calibration dataset							
CO$_2$ (mg C-CO$_2$ m^{-2} d^{-1})				CH$_4$ (mg C-CH$_4$ m^{-2} d^{-1})			
LOW	MEDIUM		HIGH	LOW	MEDIUM		HIGH
Smaller than	Between		Bigger than	Smaller than	Between		Bigger than
109	109	628	628	3	3	45	45

Table 4 Predicted values over hundred years

Predicted values

Time	CH_4	CO_2	lower limit CO_2	Upper limit CO_2	lower limit CH_4	Upper limit CH_4
(year)	(mg C-CH_4 m^{-2} d^{-1})	(mg C-CO_2 m^{-2} d^{-1})	(mg C-CO_2 m^{-2} d^{-1})	(mg C-CO_2 m^{-2} d^{-1})	(mg C-CH_4 m^{-2} d^{-1})	(mg C-CH_4 m^{-2} d^{-1})
0	290.49	1313.53	571.10	3021.12	81.83	1031.23
1	278.49	1280.02	556.53	2944.06	78.45	988.65
2	267.35	1247.57	542.42	2869.41	75.31	949.09
3	256.99	1216.13	528.75	2797.11	72.39	912.32
4	247.36	1185.68	515.51	2727.07	69.68	878.14
5	238.41	1156.19	502.69	2659.24	67.16	846.36
6	230.09	1127.62	490.27	2593.54	64.81	816.81
7	222.35	1099.96	478.24	2529.90	62.63	789.34
8	215.16	1073.15	466.59	2468.26	60.61	763.81
9	208.47	1047.20	455.30	2408.55	58.73	740.09
10	202.27	1022.05	444.37	2350.72	56.98	718.05
11	196.51	997.70	433.78	2294.70	55.35	697.59
12	191.16	974.11	423.53	2240.45	53.85	678.62
13	186.21	951.26	413.59	2187.90	52.45	661.04
14	181.62	929.13	403.97	2137.00	51.16	644.77
15	177.39	907.69	394.65	2087.69	49.97	629.73
16	173.48	886.93	385.62	2039.94	48.87	615.86
17	169.89	866.82	376.88	1993.68	47.86	603.10
18	166.59	847.34	368.41	1948.88	46.93	591.38
19	163.57	828.47	360.21	1905.49	46.08	580.66
20	160.81	810.20	352.26	1863.45	45.30	570.89
21	158.32	792.50	344.56	1822.74	44.60	562.03
22	156.07	775.35	337.11	1783.31	43.96	554.05
23	154.06	758.74	329.89	1745.11	43.40	546.90
24	152.27	742.66	322.90	1708.12	42.89	540.56
25	150.70	727.08	316.12	1672.28	42.45	535.00
26	149.35	711.99	309.56	1637.57	42.07	530.20
27	148.21	697.37	303.20	1603.95	41.75	526.15
28	147.27	683.21	297.05	1571.39	41.48	522.81
29	146.53	669.50	291.09	1539.85	41.28	520.19
30	145.99	656.22	285.31	1509.30	41.12	518.27
31	145.64	643.35	279.72	1479.71	41.03	517.04
32	145.49	630.89	274.30	1451.05	40.98	516.50
33	145.49	618.82	269.05	1423.29	40.98	516.50
34	145.49	607.13	263.97	1396.40	40.98	516.50
35	145.49	595.81	259.05	1370.35	40.98	516.50

Predicted values						
Time	CH_4	CO_2	lower limit CO_2	Upper limit CO_2	lower limit CH_4	Upper limit CH_4
(year)	(mg C-CH_4 m^{-2} d^{-1})	(mg C-CO_2 m^{-2} d^{-1})	(mg C-CO_2 m^{-2} d^{-1})	(mg C-CO_2 m^{-2} d^{-1})	(mg C-CH_4 m^{-2} d^{-1})	(mg C-CH_4 m^{-2} d^{-1})
36	145.49	584.84	254.28	1345.13	40.98	516.50
37	145.49	574.21	249.66	1320.69	40.98	516.50
38	145.49	563.92	245.18	1297.02	40.98	516.50
39	145.49	553.96	240.85	1274.10	40.98	516.50
40	145.49	544.30	236.65	1251.89	40.98	516.50
41	145.49	534.95	232.59	1230.39	40.98	516.50
42	145.49	525.89	228.65	1209.55	40.98	516.50
43	145.49	517.12	224.84	1189.38	40.98	516.50
44	145.49	508.62	221.14	1169.83	40.98	516.50
45	145.49	500.39	217.56	1150.90	40.98	516.50
46	145.49	492.42	214.10	1132.57	40.98	516.50
47	145.49	484.70	210.74	1114.81	40.98	516.50
48	145.49	477.22	207.49	1097.61	40.98	516.50
49	145.49	469.98	204.34	1080.94	40.98	516.50
50	145.49	462.96	201.29	1064.80	40.98	516.50
51	145.49	456.16	198.33	1049.17	40.98	516.50
52	145.49	449.58	195.47	1034.03	40.98	516.50
53	145.49	443.20	192.70	1019.37	40.98	516.50
54	145.49	437.03	190.01	1005.16	40.98	516.50
55	145.49	431.04	187.41	991.40	40.98	516.50
56	145.49	425.25	184.89	978.08	40.98	516.50
57	145.49	419.64	182.45	965.17	40.98	516.50
58	145.49	414.20	180.09	952.67	40.98	516.50
59	145.49	408.94	177.80	940.55	40.98	516.50
60	145.49	403.84	175.58	928.82	40.98	516.50
61	145.49	398.90	173.43	917.46	40.98	516.50
62	145.49	394.11	171.35	906.46	40.98	516.50
63	145.49	389.48	169.34	895.80	40.98	516.50
64	145.49	384.99	167.39	885.47	40.98	516.50
65	145.49	380.64	165.50	875.47	40.98	516.50
66	145.49	376.43	163.67	865.79	40.98	516.50
67	145.49	372.35	161.89	856.41	40.98	516.50
68	145.49	368.40	160.17	847.32	40.98	516.50
69	145.49	364.57	158.51	838.52	40.98	516.50

Predicted values						
Time	CH_4	CO_2	lower limit CO_2	Upper limit CO_2	lower limit CH_4	Upper limit CH_4
(year)	(mg $C\text{-}CH_4$ m^{-2} d^{-1})	(mg $C\text{-}CO_2$ m^{-2} d^{-1})	(mg $C\text{-}CO_2$ m^{-2} d^{-1})	(mg $C\text{-}CO_2$ m^{-2} d^{-1})	(mg $C\text{-}CH_4$ m^{-2} d^{-1})	(mg $C\text{-}CH_4$ m^{-2} d^{-1})
70	145.49	360.87	156.90	829.99	40.98	516.50
71	145.49	357.28	155.34	821.73	40.98	516.50
72	145.49	353.80	153.83	813.74	40.98	516.50
73	145.49	350.43	152.36	805.99	40.98	516.50
74	145.49	347.17	150.94	798.48	40.98	516.50
75	145.49	344.01	149.57	791.22	40.98	516.50
76	145.49	340.95	148.24	784.18	40.98	516.50
77	145.49	337.98	146.95	777.36	40.98	516.50
78	145.49	335.11	145.70	770.75	40.98	516.50
79	145.49	332.33	144.49	764.35	40.98	516.50
80	145.49	329.63	143.32	758.16	40.98	516.50
81	145.49	327.02	142.18	752.16	40.98	516.50
82	145.49	324.50	141.09	746.34	40.98	516.50
83	145.49	322.05	140.02	740.71	40.98	516.50
84	145.49	319.68	138.99	735.26	40.98	516.50
85	145.49	317.38	137.99	729.97	40.98	516.50
86	145.49	315.16	137.02	724.86	40.98	516.50
87	145.49	313.00	136.09	719.90	40.98	516.50
88	145.49	310.91	135.18	715.10	40.98	516.50
89	145.49	308.89	134.30	710.45	40.98	516.50
90	145.49	306.93	133.45	705.95	40.98	516.50
91	145.49	305.04	132.62	701.58	40.98	516.50
92	145.49	303.20	131.83	697.36	40.98	516.50
93	145.49	301.42	131.05	693.27	40.98	516.50
94	145.49	299.70	130.30	689.30	40.98	516.50
95	145.49	298.03	129.58	685.46	40.98	516.50
96	145.49	296.41	128.87	681.74	40.98	516.50
97	145.49	294.84	128.19	678.14	40.98	516.50
98	145.49	293.33	127.53	674.65	40.98	516.50
99	145.49	291.86	126.89	671.27	40.98	516.50
100	145.49	290.43	126.28	668.00	40.98	516.50
AVG	159.58	569.53	247.62	1309.93	44.95	566.52

AVG: Average over 100 years

(Source: Derived using UNESCO/IHA Risk Assessment Tool - Beta version.)

Table 5: Predicted values of Sardar-Sarovar RBPH using UNESCO/IHA Risk Assessment Tool - Beta version.

Age (years)	**STATION**	**Predicted gross* annual CO_2 diffusive flux ($mg\ C\text{-}C0_2\ m^{-2}\ d\text{-}^{1}$)**			**Predicted gross* annual CH_4 diffusive flux ($mg\ C\text{-}CH_4\ m^{-2}\ d^{-1}$)**			**REMARKS**	
		Predicted value	**67% confidence interval**		**Predicted value**	**67% confidence interval**		**CO_2 emissions**	**CH_4 Emissions**
			Lower limit	**Upper limit**		**Lower limit**	**Upper limit**		
8	Sardar Sarovar-Rbph	1073	467	2468	215	61	764	H	H
100		570	524	619	160	141	181	M	H

H-HIGH, M-MEDIUM

1a. CO_2 equivalents (CO_{2eq} or CO_{2equiv}): The international practice is to express GHG in CO_2 equivalents (CO_{2eq} or CO_{2equiv}). Emissions of gases other than CO_2 are translated into CO_{2eq} by multiplying by the respective global warming potential (GWP). From the 2007 IPCC report the GWP of CH_4 is shown in the table 6.5.

Table 6: GWP relative to CO_2 at different time horizon for carbon dioxide and methane

Gas name	**Chemical formula**	**Global warming potential (GWP) for given time horizon**		
		20-yr	**100-yr**	**500-yr**
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	72	25	7.6

Source: 2007 IPCC Fourth Assessment Report

Table 7: Predicted values of Sardar-Sarovar RBPH Diffusive flux in terms of tons of CO_{2eq}

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Predicted value CO_2	**Predicted value CH_4**	**TC-CO_2/yr**	**T-CO_{2eq}**	**TC-CH_4/yr**	**T-CH_4**	**T of CO_{2eq}**	**TOTAL CO_{2eq}**
($mg\ C\text{-}CO_2\ m^{-2}\ d^{-1}$)	**($mg\ C\text{-}CO_2\ m^{-2}\ d^{-1}$)**		**((44/12) x 3) x 1**		**((16/12) x 5)**	**((16/12) x 5) x 25**	**4 + 8**
1073	215	1.103	4.046	0.221	0.295	7.370	11.416
570	160	0.587	2.150	0.165	0.220	5.485	7.634

T-Tons, yr- year. 1, 2, 3, 4, 5, 6, 7, 8- columns

The above table 6.6 shows the predicted emissions from the reservoir while considering the whole surface area which is 375.33 Km^2 and later CH_4 emissions are converted into CO_{2eq} by multiplying with their respective GWP.

For carbon dioxide, the ratio of the atomic mass of a CO_2 molecule to the mass of a carbon atom is 44:12.To convert from “T of C” to “T of CO_2”, multiply by 44/12. And then multiply by the respective Global warming potential (GWP) in order to obtain the “g of CO_2eq”. Sometimes we find this noted as gC-CO_2 or tC-CO_2 (to make clear that these “g of C” refer to Carbon in a CO_2 molecule) refer **column 3, 4** in table 6.6.

Table 8 Typical reservoir conditions

Conditions	Typical corresponding conditions in reservoir
T1A1P1	Deep zone. High humic content.
T1A2P2	Littoral zone during the cold season, well aerated, low humic content and low to moderate decomposition of organic matter.
T1A2P1	Littoral zone during the cold season, well aerated, high humic content and/or highly active decomposition of organic matter.
T1A1P2	Littoral zone during the cold season, low level of dissolved oxygen, low humic content and low to moderate decomposition of organic matter.
T2A1P2	Aeration, low humic content and low to moderate decomposition of organic matter.
T2A2P2	Littoral zone during the summer season, well aerated, low humic content and low to moderate decomposition of organic matter.

- T1: reservoir bottom water temperature during winter [4^0C-5^0C]
- T2: reservoir surface water temperature during summer [20^0C-22^0C]
- P1: low pH [4.5–5.0]
- P2: moderately acidic pH [6.0–6.5]
- A1: anoxic condition [< 2 mg dissolved O_2•L^{-1}]
- A2: oxic condition [>2 mg dissolved O_2•L^{-1}]

6.7 TOTAL PREDICTED EMISSION FROM SARDAR-SAROVAR RBPH

Total predicted diffusive flux from the reservoir is 12.51648 CO_2eq Tons/Year. At depths larger than approximately 20 m, the pressure is too high for bubbles to form so there only dissolved methane can exist. So that dissolved methane will enters into atmosphere as degassing at the downstream and the predicted methane emission 24.16508 CO_2eq Tons/Year from table6.9. And the flux which are released from macrophytes are not been considered because it depends on the water quality and based on the atmospheric conditions that prevail over the reservoir. So the total predicted emission from the reservoir is equal to the sum of diffusive flux and emissions from degassing.

Total emission from the reservoir = diffusive flux + emissions of CH_4 in the form of degassing 12.516+ 24.166=36.682 T of CO_{2eq}/Year.

A model for estimating the GHGs from storage based hydropower scheme. It discusses estimation of GHG emission using various components like bubbling, upstream diffusive flux and downstream diffusive flux. It also discusses the technique of prediction of GHGs as well as its range throughout life cycle of the reservoir (100 years) with 67% level of confidence as recommended by UNESCO/IHA GHG risk assessment tool. Further the chapter discusses about the estimates of the contribution by bubbling and degassing. The model has been illustrated with the help of Sardar-Sarovar RBPH in which its predicted values has been calculated. In the first part of the calculation has been done by calculating diffusive flux by UNESCO/IHA GHG risk assessment tool and for calculating bubbling/degassing an experimental values has been considered which has been explained in this chapter. Finally the predicted values has been changed in term of $CO_{2eq.}$

CONCLUSION:

- The Organic Matter originates generates very high in this flooded area, and it acts as the primary pollutant. And find out daily temperature, mean precipitation.
- In this flooded area release high quantity of CO_2 and $CH_{4.}$
- In This past 16 years data the amount of macrophytes are gradually increased.
- The sardar sarovar dam storage capacity is very high, the water flowing from upstream to downstream level then seepage velocity also very high.
- Distribution capacity gradually decreased.

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