A CASE STUDY ON INTEGRATED APPROACH TOWARDS ENVIRONMENTAL SUSTAINABILITY OF CRITICALLY POLLUTED ZONE

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ABSTRACT

NTPC Vindhyachal, the largest thermal power station of India is situated in a cluster of heavy industries formed around Rihand reservoir in Singrauli region. The industries include thermal power plant, chemical, cement, mining etc. The emission and effluent discharges from these industries are responsible for the degradation of environmental quality affecting the bio-diversity of the region.

Thus, environmental issues in Singrauli area acquired a priority status after a comprehensive study by CPCB in early 1991. Subsequently, Singrauli region has been identified as a critically polluted area (CPA) by the Union Ministry of Environment and Forests (MoEF).After the declaration of Singrauli as critically polluted area, Government of MP & MP pollution control board has considered it seriously and necessary steps have been taken.

In light of the above fact, NTPC Vindhyachal which is located in the aforesaid critically polluted zone, has taken various proactive measures for environmental protection and mitigation. The station has specifically undertaken various unique steps with respect to design, modifications, changes in operational methodology and introduction of new technologies for monitoring, controlling and mitigation of environmental impact in the region. In this paper, these mitigation measures have been described with special emphasis upon:

- Zero effluent discharge
- Inventorization study of Rihand reservoir
- Fly ash utilization by filling in abandoned Gorbi Mines
- Installation of Flue Gas Desulphurization (FGD) plant

1.0 INTRODUCTION:

Environmental sustainability is defined as responsible interaction with the environment to avoid depletion or degradation of natural resources and allow for long-term environmental quality. The practice of environmental sustainability helps to ensure that the needs of today's population are met without jeopardizing the ability of future generations to meet their needs.

Throughout the nineteenth and early twentieth centuries, environmental sustainability focused on the preservation of land, wildlife, water, and air resources throughout the world. The significance of these feats was furthered in 1969 by the first establishment of a United States national policy for environmental sustainability with the passage of the National Environmental Policy Act (NEPA). The purpose of the NEPA was to, “foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony and fulfill social, economic and other requirements of present and future generations”. Therefore, it is very important to emulate the model of environmental sustainability to ensure that there remains a balance and interconnectedness of human society and the environment’s needs[1]. As the world moves toward what Thomas Friedman called the “green revolution”, people throughout the world are seeking to decrease environmental damage and establish more environmentally friendly practices[2].

The Central Pollution Control Board (CPCB) has identified half of the 88 industrial clusters in India as critically polluted[3].In the recent times, the Government has initiated various measures to promote industrial development in an environmentally sustainable manner. The ASEM (Advisory Services in Environment Management) program was started in 2002 in a collaborative effort between the Ministry of Environment and Forest and GIZ (the German International Society for cooperation). The program provides technical support for the development of pilot measures to enhance environmental sustainability in urban and industrial areas. The recently approved National Manufacturing Policy (NMP) has made wastewater treatment and rain water harvesting compulsory for industries under the zone[4]. An environmentally sustainable industrial growth path is thus required to prevent environmental degradation and achieve targeted industrial growth.

There is a cluster of heavy industries including thermal power plants, chemical plants, cement manufacturing plants, mining etc. around Rihand reservoir in Singrauli district of Madhya Pradesh. The

emission and effluent discharges from these industries are responsible for the degradation of environmental quality affecting the biodiversity of the region.
Thus, environmental issues in Singrauli area acquired a priority status after a comprehensive study by CPCB in early 1991. Subsequently, Singrauli region has been identified as a critically polluted area (CPA) by the Union Ministry of Environment and Forests (MoEF)[5]. After the declaration of Singrauli as critically polluted area, Government of MP & MP pollution control board has considered it seriously and necessary steps have been taken.

2.0 NTPC VINDHYACHAL TOWARDS ENVIRONMENTAL SUSTAINABILITY:

NTPC Vindhyachal being the largest thermal power station in the country having installed capacity of 4760 MW has been significantly contributing to the electricity requirement of the country. The station is equally delivering its commitment towards the protection of the environment, society and various stakeholders, thus meeting the requirement of all the key elements of sustainable development. In way forward towards sustainability, the station has undertaken various environmental mitigation and control measures, some of them are hereby discussed in this paper.

2.1 Zero effluent discharge

Water consumption of about 12000-14000 m^3/hr is used for meeting the requirement for raw water, clarified water, DM water, drinking water etc. for all the stages.
During usage of above water drain water collected is routed through liquid waste treatment plants and discharged after treatment. Following are the outlets for the drain water:

S. No.	Location of Pump House	Name of Plant Drain	No. of Pumps Installed.
1.	Main Plant Drain Collection Sump Near ETP-1 of Stage-1(Lamella-1)	Drain ultimately going to Suryanala	04 Pumps
1a.	----do----	----do----	02 Pumps
1b.	Pumps installed near Raw Water Pump House PTP-3	----do----	02 Pumps
2.	Pumps Installed near new Labour Gate for Stage-2 Zero Discharge	Labour gate Drain ultimately going to Suryanala.	02 Pumps
3.	Pumps Installed at South West Waste disposal Pump House for Stage-3 Zero Discharge	EDC Drain ultimately going to Suryanala	05 Pumps
3a.	Pumps installed near ETP-3 Pump House (Lamella-3)	----do----	03 + 02 Pumps
4.	Drain Collection Sump Near Stage-4	Drain ultimately going to BaliaNala	02 Pumps
4a.	Pump House near Watch Tower-8 (North side waste collection sump)	----do----	04 Pumps

Presently, NTPC VSTPP is having four effluent treatment plants for recycling of waste water. Besides these, Chemistry department has taken an initiative for utilizing standby clariflocculator to reuse & recycle effluents of the plants which is depicted in Fig. 1.

Fig. 1 Use of standby clariflocculator for recycling waste water.


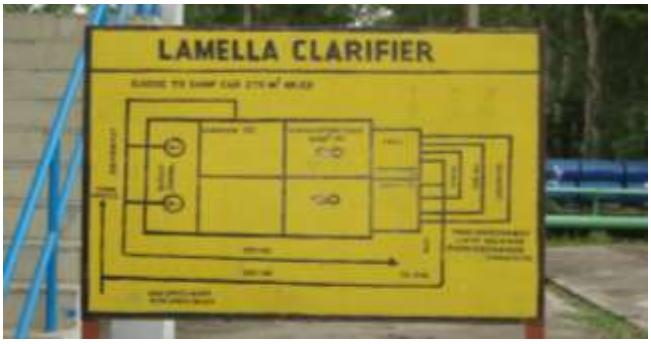

Fig. 2 Liquid Waste Treatment Plant Stage I

2.1.1 Calculation of percentage of recycled water:

NAME OF ITEMS	Recycled Amount (m^3/hr)
Process Water in Stage # I	4020
Process Water in Stage # II	3350
Process Water in Stage # III	3350
AWR System in Stage # I	3000
AWR System in Stage # II	1800
AWR System in Stag # III	1500
LWTP/ETP Systems for Stages # I, II & III	2825
Sewage treatment plant	1500
Auxiliary Cooling System Stage # I	29100
Auxiliary Cooling System Stage # II	19400
Auxiliary Cooling System Stage # III	18200
CW system in Stage # I	165000
CW system in Stage # II	120500
CW system in Stage # III	105000
TOTAL WATER RECYCLED	485545 m^3/hr = 4758.34 cusec

Total Make-Up Water in Stages - I, II & III Units is 10542 m^3/hr = 104.0783 cusec
Percentage of Recycled Water used as Input Water is: {4758.34 / (4758.34 +104.078)} x 100 = 97.86 %

2.2 Inventorization study of Rihand reservoir

Govind Ballabh Pant Sagar (also known as Rihand Reservoir named on river Rihand) is an artificial dam situated in Sonebhadra district of Uttar Pradesh. Rihand river, along with five other rivers, flows in to Son river which finally meets Ganga. Sonebhadra district borders four states namely Madhya Pradesh, Chhattisgarh, Jharkhand and Bihar. It is surrounded bounded by Mirzapur District to the northwest, Chandauli District to the north, Kaimur and Rohtas districts of Bihar state to the northeast, Garhwa district of Jharkhand state to the east, Koriya and Surguja districts of Chhattisgarh state to the south, and Singrauli district of Madhya Pradesh state to the west and is heavily forested. The Rihand dam comprising of 61 blocks runs a length of 934.21 m with maximum height of 91.44 m.

This region (part of UP, MP, Jharkhand, and Chhattisgarh) has been named as Energy Capital of India[6] due to large reserves of coal and many thermal power plants operating in this zone producing more than 15000 MW of electricity. The major power plants and chemical industries located in this area are:

POWER PLANTS	
Rihandnagar NTPC	Renusagar UPRVUNL
Shaktinagar NTPC	Pipri UPRVNUL
Vindhyanagar NTPC	Essar power
Anpara UPRVUNL	Jaypee Power
Obra UPRVUNL	Aditya Birla Project (Mahan project)
Sasan Super Thermal Power Station	

CHEMICAL INDUSTRIES	
Churk Cement Factory,	B.P. Construction company
Hindalco Aluminium Plant,	Hi-Tech Carbon
Kanoria Chemicals	Bhaskar group
Dala Cement Factory	Chunar Cement Factory

Due to such intense industrial operations, a large amount of wastewater is generated which with or without adequate treatment is discharged in to Rihand Reservoir in addition to other sources. This adversely affects not only the life supporting water quality of the reservoir, but also its structural and capacity related aspects.

Recognizing the damage to the reservoir and impacts of these industries and other activities to the total pollution load in the region, NTPC Vindhyachal is conducting 'Inventorisation study for the inventory of the industries operating around the Rihand Reservoir periphery to ascertain the effluent getting discharged directly or indirectly in the water body and also to carry out air emission inventory'.

2.2.1 Objectives of the study:

- Identification of the watershed region of the Rihand reservoir region
- Shortlisting of various activities taking place that generate significant volume of effluents / wastewater / sewage within the region.
- Identification of various industries / industrial sectors located around the periphery of the Rihand Reservoir.
- Inventorization of the various industries located in the watershed region along the following categories shall depend on data obtained from public sources, including such agencies as the state pollution control board.
- Quantification of effluents generation in the region
- Development of seasonal water balance (covering post monsoon, winters and summer) for the Rihand reservoir.
- To prepare air emission inventory accounting for various sources within 15km periphery of the Rihand Reservoir.

2.2.2 Methodology:

A. Inventory of the industries operating around the Rihand Reservoir periphery to ascertain the effluent getting discharged directly or indirectly in the water body

The study will be conducted through Material Flow Analysis (MFA) approach. Material flow analysis (MFA) refers to analysing the throughput of process chains comprising extraction or harvest, chemical transformation, manufacturing, consumption, recycling and disposal of materials.

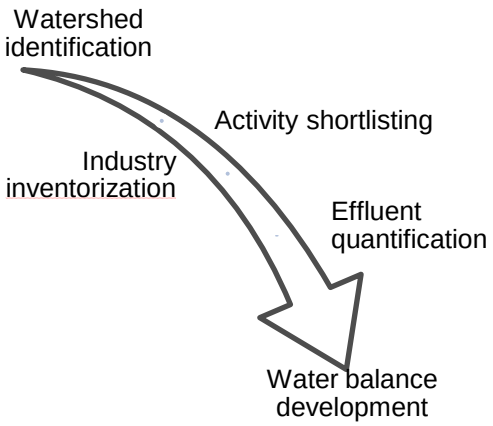

Figure 3 Schematic Representation of the Activities to be undertaken for the proposed outcome

a. Season wise analysis of heavy metals shall be done for the water samples collected by dividing the Rihand Reservoir into grids of appropriate size say 2 x 2 Km^2

b. Season wise Heavy Metals Analysis shall be done in the sediments samples collected from Rihand Reservoir by dividing the reservoir into grids.

B. Development of air emission inventory

The development of comprehensive emission inventory is an important tool in air quality management process. Emission inventory is a quantitative compilation of air pollutants emitted from all source categories (both mobile and stationary) in a certain geographical area within a specified time span.

A reconnaissance survey will be carried out in the study domain (within 15 km. from Rihand Reservoir) in order to identify various sources contributing to ambient air pollution in the region. Secondary

information/data such as city maps, demography, vehicular data, traffic patterns, road conditions, festivals and seasonal activities, industrial emissions data, DG sets, construction patterns will be collected from reliable sources.
Emission inventory will primarily be focussed on criteria air pollutants i.e. PM10 or PM2.5, SO_2 and NOx, for all the identified sectors.

2.3 Fly ash utilization by filling in abandoned Gorbi Mines:

Fly ash is a byproduct of power generation with coal. Sustainable ash utilisation is one of the key concerns at NTPC. The Ash Utilisation Department of NTPC Vindhyachal strives to derive maximum usage from the vast quantities of ash generated and is constantly looking at innovative and new ways to utilize the ash generated.

2.3.1 Mine Filling:

Research study is being done by the Central Mine Planning and Design Institute (CMPDI), Ranchi for taking up technology demonstration project for random filling of ash from NTPC Singrauli into the abandoned Gorbi Mines of NCL (Northern Coalfields Limited). The salient points of the report on hydro-geological investigations & EIA studies for filling NTPC Singrauli ash in abandoned Gorbi mines by CMPDI, Ranchi are:

- Impact Assessment and mitigation measures have been spelt out for the following activities:
  a) Transportation of ash from power house end to rail head end
  b) Ash handling and storage at rail head end
  c) Ash transportation from rail head end to mine void
     - *Dry form*
     - *Wet form*
  d) Ash placement in mine voids
     - *Dry form: Through dumpers/trucks or Pipe Conveyors*

     It is not feasible. It will not be safe to ply the Grader or Dozer on ash filled up area during the monsoon season because in this season, the ash mass will be saturated and hence CBR will be low and at low CBR, it may not support the load of Grader or Dozer.
     - *Wet form: in slurry form*

     Slurry will be formed either at Rail Head end or Mine pit.It will be disposed off in pit through a no. of disposal points located around the pit rim.The disposal will be started only after the pit has been totally dewatered.It is proposed to fill the Pit-1 in first phase.It is proposed to provide a layer of top soil of depth 1m over the filled up area and also to plant trees (local species) over the physically reclaimed area.
- It is recommended that the pit water be neutralized and pumped out prior to placement of ash in slurry form.
- Delivery of ash to the mine pit lake from the dry ash silo is recommended in the form of slurry. US Experts have recommended the slurry of 60% solids and 40 % water.

Based on the above studies, NTPC Vindhyachal had conducted various meetings with NCL to convince them to give their consent for backfilling of abandoned Gorbi Mines of NTPC Vindhyachal. By the continuous efforts, on 14.09.2016, NCL authorities gave their consent with the condition that the permissions from MPPCB, MoEF and conducting various studies will be the responsibility of NTPC Vindhyachal. After this MoU may be signed between NTPC Vindhyachal and NCL. A draft MoU has also been prepared by both the parties and will be signed very soon.

2.3.2 Activities Involved for Gorbi Mine filling:

S. No.	Activities / Issue	Input /Clearance Required
1	Meeting with DM, Singrauli regarding Ash filing in Gorbi Mine along dedicated road corridor	
2	Signing of MoU with NCL	a. Draft MoU from NCL is received. b. NCL awaiting clearance from Coal India c. Coal India soughts clarification from NCL.
3	Letter to NCL to initiate the activities for obtaining clearance of DGMS for ash filling in Gorbi Mines.	Letter sent on 24.11.16. Discussed with NCL further, they will take up with DGMS once the MoU is signed.

4	Joint visit of DGMS Varanasi with CMPDI & NCL for establishing the requirement of DGMS Clearance.	
5	Application to pollution control board for permission of Ash Filling	a. Letter already given to MPPCB for permission of Ash filling in Gorbi Mines and for conducting Studies required for grant of permission. b. Further discussed with Member Secretary MPPCB.
6	Studies for Environment Clearance a. Hydro geological Investigation b. Ash leachate /Characterization of Ash Study c. Radioactivity Study d. Baseline survey for assessing impact on flora and fauna e. EIA and mitigation Plan covering related treatments.	TOR required from NTPC CC-Env. Engg and Ash Management Group, for award of study from Site.
7	Devising methodology for neutralization of Acidic water and dewatering the mine voids	TOR required from CC-Env. Engg for awarding study
8	Permission from DGMS (To be obtained by NCL)	Clearance required for Ash filing.
9	Submission of application document to MoEF for permission	Studies conducted by site are required to be approved from CC-EnvEngg.
10	Obtaining forest clearance (Change of Land Use) if any	CC-EnvEngg to coordinate
11	Identification of any clearance required under CBA act	In association with NCL
12	Finalization of dedicated corridor for road transportation of Fly Ash through closed trucks	In association with FES
13	Preparation of technical report for loading, transportation, unloading and ash slurry formation at mine end.	To be carried out for transportation of dry fly ash taken from the silo.
14	Formulation of methodology for disposal of ash in the pit.	
15	Supplementing of loading infrastructure at power station	
16	Creation of unloading and ash filling infrastructure at mine end.	
17	Proposal for transportation of fly ash transportation work in closed trucks.	
18	Start of dewatering and ash filling work	

2.4 Installation of Flue Gas Desulphurization (FGD) plant:

NTPC Vindhyachal will be the first station in NTPC to commission Flue GasDesulphurisation plant to reduce sulphur dioxide emission in flue gas in its Unit # 13 by March 2017.

CHEMICAL REACTION

$$CaCO_3 \text{ (Limestone)} + H_2O = Ca(OH)_2 + CO_2$$
$$Ca(OH)_2 + SO_2 = CaSO_3 + H_2O$$
$$CaSO_3 + 3H_2O + 1/2O_2 = CaSO_4.2H_2O \text{ (Gypsum)} + H_2O$$

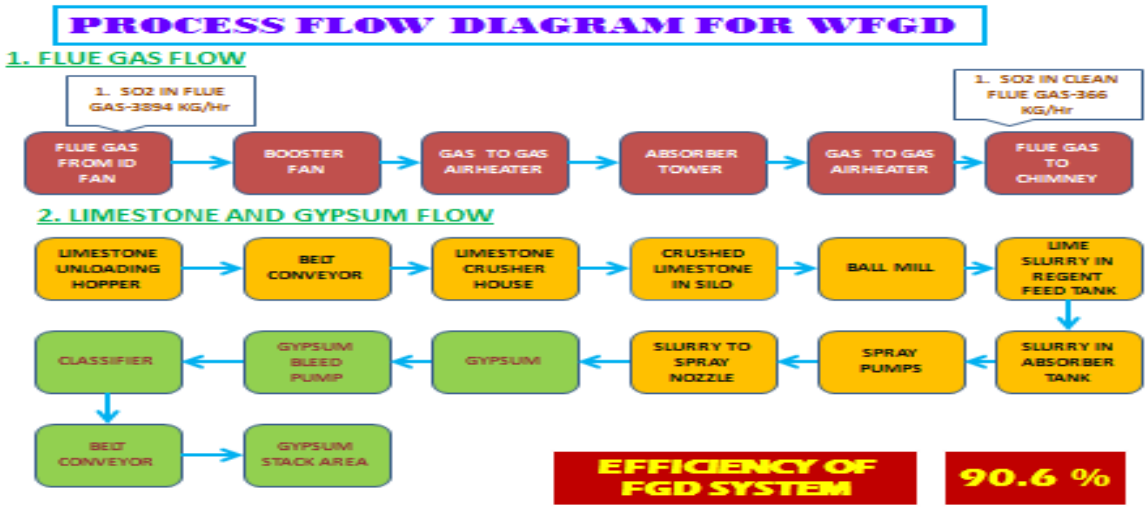

Fig. 4 Process Flow Diagram of WFGD installed at NTPC VSTPP

The FGD system has been supplied by M/s Alstom and is designed for SO_2 removal efficiency of a 90.6% or greater under guarantee point conditions at 500 MW unit load with worst coal firing.

Fig.5Aview of FGD system at NTPC Vindhyachal

2.4.1 Calculation of Month-wise Gypsum production Jan 2017- Mar 2018

MONTH	Generation (MU)	Sp. coal	Coal consumption (T	Sulphur content (T)	95% Sulphur (T)*	SO_2 generated (T)	90% Removal (T)**	GYPSUM (T)
Jan 17	163	0.66	107580	376.53	357.7035	715.407	643.8663	1732.10
FEB 17	293	0.66	193380	676.83	642.9885	1285.977	1157.3793	3113.53
MAR 17	325	0.66	214500	750.75	713.2125	1426.425	1283.7825	3453.58
APR 17	351.9	0.66	232254	812.889	772.24455	1544.4891	1390.04019	3739.43
MAY 17	324.3	0.66	214038	749.133	711.67635	1423.3527	1281.01743	3446.14
JUN 17	340.7	0.66	224862	787.017	747.66615	1495.3323	1345.79907	3620.41
JUL 17	308	0.66	203280	711.48	675.906	1351.812	1216.6308	3272.93
AUG 17	236.9	0.66	156354	547.239	519.87705	1039.7541	935.77869	2517.39
SEPT 17	300.5	0.66	198330	694.155	659.44725	1318.8945	1187.00505	3193.23
OCT 17	361.7	0.66	238722	835.527	793.75065	1587.5013	1428.75117	3843.56
NOV 17	314.1	0.66	207306	725.571	689.29245	1378.5849	1240.72641	3337.75
DEC 17	306.2	0.66	202092	707.322	671.9559	1343.9118	1209.52062	3253.80
JAN 18	253.2	0.66	167112	584.892	555.6474	1111.2948	1000.16532	2690.60
FEB 18	304.1	0.66	200706	702.471	667.34745	1334.6949	1201.22541	3231.48
MAR 18	350.3	0.66	231198	809.193	768.73335	1537.4667	1383.72003	3722.42
TOTAL	**4532.9**							**48168.35**

* It has been assumed that 95% of total sulphur will get converted to SO_2

** 90% Removal of SO_2 by FGD

2.5 Additional measures taken by NTPC Vindhyachal in the area of Environment Management:

- **Pilot project for De NOx system:**
  NTPC and GE Power India Limited has signed test protocol for Selective Catalytic Reduction (SCR), Selective Non-Catalytic Reduction (SNCR) and hybrid system and agreed to carry out pilot testing at Unit # 13 of Vindhyachal STPP. For this purpose, a team of GE visited NTPC VSTPP in the month of November 2016 alongwith NTPC Engg/OS team and site representatives from various departments in order to identify the suitable location for slip stream for SCR & SNCR pilot plant and identification of terminal points of various consumables/Utilities like dry compressed air, Ammonia, Urea etc.

- **Pilot project for CO_2 capturing:**
  The reduction of CO2 emissions to the atmosphere is one of the tasks in combating the warming of the atmosphere and consequently reducing the negative impacts of global change of the environment. Carbon capture and sequestration (CCS) is considered as one of the options for mitigating the greenhouse gas emission. Among the different technologies under development for precombustion CO_2 capture, pressure swing adsorption (PSA) looks promising due to the inherently low energy consumption if the feed stream is already at high pressure. In view of the above fact, NETRA has decided to take up this project with IIP Dehradun at NTPC Vindhyachal. Under this project, CO_2 from flue gas will be captured using PSA technology with developed patented adsorbents.
  It is decided that the scale up demonstration project may be installed at the space near Flue Gas duct after ID Fan Discharge in unit 12 or 13. The exact location will be decided during the site visit by NETRA along with Station soon.

- **R & M of ESPs of Stage I & II:**

Renovation of ESPs of Stage I & II units are in progress with a target to lower the SPM values better than the statutory norms.After R&M, guaranteed SPM value in unit 1 to 6 shall be 75 mg / NM^3 and Unit-7 &8, SPM shall be 68 mg/NM^3. The contract for this renovation job has been awarded to M/S BHEL and the work will be completed by Dec 2017.

- **Afforestation programme:**
  NTPC Vindhyachal has planted 20.67 lakhs of trees so far and this year 25,000 nos. of plants are being planted as per target, some of which are used to synthesize bio-diesel, in its periphery. The station has also made MOU with MPRVVN for massive tree plantation programme of 05 lacs of trees in M P w.e.f. 2016 for ten years. The station has also undertaken various innovative measures such as numbering of trees, mass tree plantation involving employees on various occasions etc.

3.0 CONCLUSION:

With the massive expansion of power generation, there is also growing awareness among all concerned stakeholders to keep the pollution under control and preserve the health and quality of the natural environment in the vicinity of the power stations.With the key focus for NTPC now being environmental sustainability, NTPC Vindhyachal is committed to incorporate environmental sustainable development principles into its industrial and commercial developments. This study will provide vital comprehensive information towards making conclusions and anticipating the future growth of environmental sustainability in the power industry.

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