HYDROTHERMAL POWER STATION APPLICATION AND BIODIVERSITY OF HOT WATER SPRING TATAPANI (HWST) BALRAMPUR, CHHATTISGARH, 417119, INDIA.

Divya Mahar[1], Durgesh Mahar[2], H D Mahar[3]

[1]Department of Microbiology, Philosophical Society, Ledari, Manendragarh C.G. India
[2] School of Life Science. Devi Ahilya Vishwavidyalaya, Indore, M P, 452010, India
[3]Department. of Botany, RG PG Autonomous College, Ambikapur, C G 497001 India

***Abstract*--An exploration of a hot water spring tatapani (HWST) was done at the atmospheric temperature 29^0C. Geographic position of HWST is 23^0 69^I N latitude, 83^0 66^1E longitude and 461.00 meter altitude. Temperature of HWST was measured and its thermoelectricity was studied. The scope of hydro thermal power generation is studied. Water sample was collected in sterilized thermos flasks. Hydrophytes were collected from the pond made by HWST and identified. Soil chemistry of HWST is discussed.**

***Index Terms*-- Hydrothermal power, C.G.hydropower, geo thermo logy, Hot water spring, Tatapani, Balrampur CG.**

I. INTRODUCTION

A hot spring is a spring produced by the emergence of geo thermally heated groundwater that rises from the Earth's crust. While some of these springs contain water that is a safe temperature for bathing, others are so hot that immersion can result in injury or death. Since, behind hot water spring, there is deeper earth hotter, it gets found magma (molten rock) at the outer core of the earth. This magma (8000C to 1300°C) is surrounded by different layers of the earth.[1] There are hundreds of hot water spring on the globe and seven in India

In Hindi Tata= Hot and Pani = Water , Thus , it's name of the spring is Tatapani , and many hot springs are named as Tatapani in India Like Tatapani in Orisa, Tatapani of Himanchal Pradesh, Tatapani of Surguja etc. A thermal springs having water warmer than 98°F (37°C): the water is usually heated by emanation from or passage near hot or molten rock.[2]. Sergio Guajardoet al studied microorganisms found in microbiology and identified thermo philic Virus and bacteria [3] Gouri Shankar Mishra et al studied realizing the geothermal electricity potential studied hot water use and consequences [4,5,6]

Lawal, Sule and Ogunlela studied in 2014 , an application of hydro powers in social sectorin Nigeria in agronomy and water falls for electric generation [7]. Jack D. Farmer did hydro thermal study in organic evolution and environmental aspects like evolution of thermo philic microbes and chemical changes in hot water field.[8]. Kanoglu, and Engel (19999) thought of probe of Power Plant applying geo thermal energy.[9]. Wang and Xun Zhou in 2019 studied hotsprings in Yunlong County of Yunnan in Southwest China and determined the source of geothermal energy.[10] Robin W Renaut and Brian Jones studied Sedimentology of hot spring systems and its application in social cure and comfort by specific chemistry of hot springs .[11] Ou Bai et al (2004) studied hot spring thermal energy conversion system that converts heat energy into electricity using the temperature difference between hot spring water and sea / river water.[12,13]

Alexander Richter (2017) thought upon geothermal power project on proposed study at Tatapani to consider that the temperature of hot spring is directly proportion to its depth. Thus the drilling would be needed to produce such temperature gradient [14] and for establishmentIndia Central government's National Thermal Power Corporation (NTPC) and Chhattisgarh state's Renewable Energy Development Agency (CREDA) are jointly proposed the plan for the implementation of the project. Scientists have a view that if HWST is made a hole up to two Kilometers, temperature of hot water spring could be found 200^0C. [15 - 18]. Objective of the study is to explore the possibility of HWST for power generation along with study of it's biodiversity and possibility of thermo electrical generation.

Fig.1 HWST source

Fig 2 Geomorphology of HWST

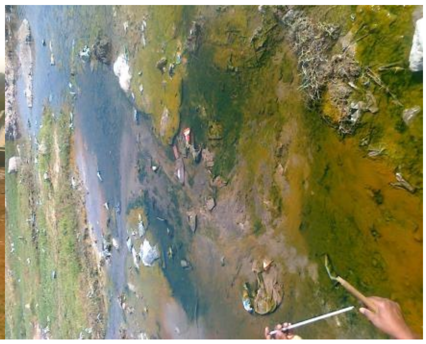

Fig 3 Out Drainage of HWST

Fig 4 Soil Collection

Fig 5 Temp. Measurement

Fig 6 Water Collection

II MATERIAL AND METHOD

An exploration of hot water spring "Tatapani" (HWTP) under Balrampur District, 80 Km.distance from Dept. of Botany was done .The geographic position at Tatapani spring is 22^0 41^I latitude and 83^0 38^1 altitude . The atmospheric temperature at the time of visit to hot water spring "Tatapani" was 29^0C at the distance of 1.0 Km, while the atmospheric temp. above the hottest point of water spring "Tatapani" was 30^0C. Thus, the environmental temperature increases by 01^0C. Fig 1 represents the hot spring source, Fig 2 represent Geomorphology and fig 3 represents water drainage made up by HWST.

The temperatures of hot water spring have been measured and water sample is collected in sterilized thermos flasks. This was done at three deferent 4 points of hot water springs having temp. 85^0C, 70^0C, 60^0C and 42^0C. Simultaneously the water samples were collected in sterilized thermos flasks. Also, soil sample of the soil around the hottest spring has been collected, it is depicted in fig 4 while fig 5 represents temperature measurement and fig.6 represents the collection of water sample of HWST. Microscopic observation of the collected water sample was done in laboratory and also, the soil testing had been done. The properties of the hot-water spring surrounding soil was compared with the other districts soil samples. The thermophilic microbes and planktons were examined under compound microscope.

III SULPHATE AND PH TEST OF HWST

HWST water flows to make a drainage and mud, 20ml water of it took in a test tube ad init 20ml concentrated Hydro chloric acid (HCL) was added carefully. Then it is boiled and after some cooling Barium chloride added and observed white precipitation on further heating. Barium chloride reacts with soil's sulphate ions, thus, white barium sulphate is precipitated. While when about 200gram common soil in a conical flask and added 500 ml. distilled water and shacked it well. After a night decanted water is transferred into a glass beaker .took 20ml water of it and didrepeat the sulfate test only milky color is seen at heating and hardly. This proves to be higher amount of Sulfur in HWST. Fig 7 represents first soil test of HWST and second of common garden soil with no precipitation, but white color sowing less sulfate.

For the pH test, pH meter, (Model HWST, Handy pH 365) was calibrated and electrodes were dipped into soil solution of HWST observed pH 8.5 (basic), while common garden soil was found 6-5 (acidic) .Fig 8 represents pH measurement and figure9 represents pH confirmation with litmus paper.

Fig 7 Comperative sulphate test

Fig 8 pH measurement

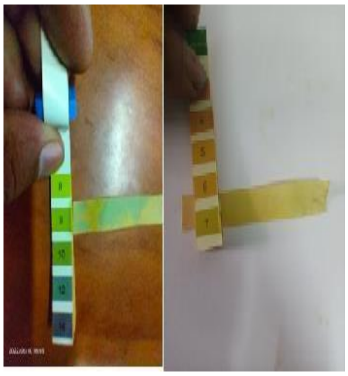

Fig.9 Litmus peper test

IV RESULT AND DISCUSSION

1. The environmental temperature increases by 01^0C at HWST.
2. Geomorphology, soil texture and color and soil chemistry are observed different from its 0.04 Km. distance. Fig1, Fig2 and Fig 3 represent comparative geomorphology. Fig7 represents that most hot water spring surface view where water temp. is 85^0C. Figure 8 represents lives in the most less hot water spring having temperature 42^0C. Fig 9 represents higher hydrophytes on the pond made by HWST water Drainage.

3. Table -1 represents comparative soil chemistry, with the soil surrounding HWST and other district's soil samples. Table 2 represents the temp. at different points of HWST and microbes present in it. Fig11 represents Microscopic study of water Sample collected from HWST. Fig 12 depicts thermopiles microbes under high power microscope.
4. Soil of HWST has much more Sulfur giving Sulfate test clear and pH is 8.9 basic natures.

Table 1: Comparative properties of soil samples taken from Tatapani, surrounding hot water spring, Balrampur (10 Km distance) , Ambikapur(80 Km distance)and Manendragarh (MDGR 200 Km. distance).

Sr_N0	Character/ Soil Sample	Tatapani	Balarampur	Ambikapur	Manendra garh
1	pH	8.50	6.4	6.5	6.4
2	Electrical conductivity(m.mol/cm.)	0.06	0.07	0.06	0.11
3	Organic Carbon%	0.43	0.36	0.43	0.42
4	Phosphorous (P_2O_5 Kg/Hect.)	25.00	12.81	25.00	26.00
5	Sulfur salts (mg/Kg soil)	0.16	0.03	0.02	0.02
6	Potassium Salt (Kg/Hect.)	32.2	27.0	28.2	30.3

Table 2. Microbes of hot water spring tatapani at different temperature

Srl.	Temperature	Class	Organisms
1	42^0C	Algae	filametous chlorophyceae e.g. *Spirogyra.*
		Fungi	Phycomycetes and plasmetis,
		Protozoa	*Euglena*
		Bacteria	Sulfur bacteria e.g. *Desulfo vibria*
2	60^0C	Bacteria	*Paralvinella sulfincola* , *Halicephalobus mephisto* and *Tardigrada,*
3	70^0C	Bacteria	*Chloroflexus aurantiacus, Deinococcus radiodurans,Deinococcus-Thermus, Spirochaeta americana,*
4	85^0C	Bacteria	*Thermus aquaticus,*

V Geo hydro thermal application of Tata pani

The hydrological parameters and physical forces of HWST are just equal to that of measured in Ultapani [21]. The highest temperature of HWST is 85^0C. When a thermocouple Fe- Cu wires a junction is dipped in it and another junction put ice bath in electric circuit with the thermo electric current was found 45uA. [22,23] This very feeble result therefore scientists are view of dig a hole up to 2.00 Km to get temperature up to 200^0C [24,25] to established geo- thermal power project at Tatapani, with Central government's National Thermal Power Corporation (NTPC) and with Geological Survey of India and National Geographic Research Institute, Hyderabad The Project has been taken up under aegis of Chhattisgarh Renewable Energy Development Agency (CREDA) in association.[26,27]

Steven Earle et al described in his e-book Physical geology [28], *i.e.* "Earth's internal temperature increases with depth although the rate of increase is not linear. The temperature gradient isaround 15° to 30°C/km within the upper 100 km; it then drops off dramatically through the mantle, increases more quickly at the base of the mantle, and then increases slowly through the core. The temperature is around 1000°C at the base of the crust, around 3500°C at the base of the mantle,
and around 5,000°C at Earth's centre. The temperature gradient within the lithosphere (deeper100 km) is quite variable depending on the tectonic setting". Therefore, whether we can establishCryo station at Tatapani. For Tatapani power plant establishment at HWST, Scientists think of cost of production is moremuch more than out come by observed result so feeble. It is in meu ampere while needed is mega ampere. At the depth of 2 km drilling can be find temp. 200"C [29]. But bore well and settlement estimate is so high than transport cost from already set power plants. Therefore at anygeothermal spring is not used as power plant. But Science is possibility and could be done withcryo - observatory. In this way, We can increase temperature gradient apart from drilling hole to

fix a junction of thermo couple in deep high temperature and another junction in to liquid Nitrogen. Local Scientist are of the view that the management cost would increase than electricproduction cost. But if a hydro geo thermal power station is well established, there is further chance for improvement.

VI. FURTHER SCOPE OF THIS STUDY

Abstraction of *Thermophilus aquaticus* bacteria and obtain restriction enzyme could be done due to high temperature of water. Although, it's costly to maintain temperature in laboratory. Also, restriction enzyme obtained from E coli. is comparatively cheaper. Secondly, Soil science and chemical analysis be thorough studied. Author was surprised to observe more clear Sulfate ($So4^{-2}$) test, but found nature basic, *i e.* pH 8.5 . It Simulates that Sulfate ion to be in salt form along with hydroxides should be of Calcium, Magnesium or Iron, and finally, There is yet not veryclear of the cause to be so much hot 85 ° C water. We only thought of to be ignaceous rock or volcanic heat. Hence Geophysical parameters along with the impact of cancer line passing besideit are need to study along with study of cast reduction to establish geo thermal power station.

VII BIODIVERSITY OF HWST

Figure 7 represents bottom structure of a HWST flowing 85^{0}C water, while Fig 8 represents HWST flowing water at 42^0. K D Frank discussed Sulfur testing in Soil and its effect in the vegetation.[19] Table1 represent comparative Sulfur quantity is increased in HWST surrounding soil. while the microbes number is not affected. But obviously, the habitat (sulfur- loving and thermopiles) changes. "Encyclopedia of plants by J C Loudon" and "Floral diversity byNaik and Mishra", [20-21] studied in the identification of hydrophytes in the pond made by HWST water drainage depicted in figure 9 are described following:

Fig7 HWST at 85^{0}C

Fig 8 HWST at 42^{0}C

Fig9.HWST Hydrphytes

Fig. 10 Microscopic study

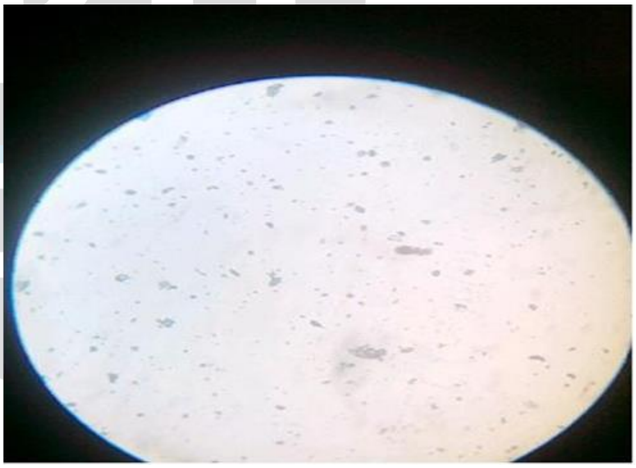

Fig.11 Microbes under microscope

1. Cape leadwort (*Cyprus auriculata*) Cyperaceae,: Tufted annual herb, Stem slender compressed tetra angular, Linear basal leaves Spikelet inflorescence, Fruits white ovoidnuts..
2. Hoorah grass *(Fimbristylis miliacea)* Cyperaceae *:* Small annual Stem slender compressed tetra angular, Linear basal leaves Spikelet inflorescence with 3-5 rays, whiteflowers, glumes fruits.
3. Pipe wort, hat pin and bog button, *(Irriocaulon rotundifolia*) : Cyperaceae, Small annualherb, Marshy tuft, leaves absent apical

globular flowers of white color, showy.

4. Club-rush, wood club-rush or bulrush (*Scirpus auriculata*) : Cyperaceae, annual sedge,amphibian, fibrous roots, Stem--erect hollow, ternate, spongy, Leaves-in juvenile stage under water, ovoid spikelet's, Glumes fruit Ovate.
5. Bog bulrush, rough-seed bulrush (*Scirpus mucronatus*) : Cyperaceae, Annual herb, 25 Cmlong tufted leaves absent pseudo lateral capitates inflorescence spike oblong, fruits nut blackish.
6. Drop seeds or sacaton grasses (*Sporobolus diander*): Poaceae, Perennial herb, Grass of 50cm tall, leaves- linear, filli form with glabrous sheath , ligules hairy, purple-grayish panicle,fruits white caryopsis, oblong ovoid.
7. Drop seeds or sacaton grasses (*Sporobolus coromundelianus*) Poaceae, Annual herb, Upto40 cm tall, erect, tufted , linear leaves bristly in margin ,Ligules hairy, open panicle inflorescence, grayish green flowers, fruit minute achene.
8. Foxtail, yellow bristle-grass, pigeon grass, and cattail grass.(*Setaria plumila*) Poaceae,Annual herb, 40-50 cm. tall, erect, decumbent, with un branched bulbous penicle - inflorescence
9. Kutela , Chiktu, Chikaniu (*Setaria intermedia*). Poaceae, Annual herb, 15-20 cm tall, Erectbranched glabrous nodes, Leaves long,, inflorescence solitary or paired spikelet, fruits brown caryopsis.
10. Yellow Water Corn (*Spalidium flavidum*), Poaceae, Perennial herb, Tufted, sub erect, 20-70 cm tall, leaves glabrous, inflorescence pikes, alternate to axis, common fodder grass.
11. Sawa, Little millet (*Penicum sumatrense*) Poaceae, Annual herb, 30Cm. erect, folded linear leaf, ligule hairy, panicle inflorescence, fruits round and smooth 1.5 mm. diameter .
12. Spear grass (*Heteropogon contartus*) Poaceae, perennial tussock grass, Erect,1.5 meter, The awn becomes twisted when dry and straightens , dark seeds with a single long awn at one end becoming embedded in the socks and skin of hikers.
13. Chhir ghas Cogon grass (*Imperata cylendrica*) Poaceae, Perennial grass, 0.6-3 m The leaves are 2 cm wide near the base of the plant and narrow to a sharp point at the top; themargins are finely toothed .The main vein is a lighter color.
14. Doob, Bermuda grass, dog's tooth grass, Bahama grass, devil's grass, couch grass, wiregrass and scotch grass (*Cyanodon dectylon*) Poaceae; Common creeping grass, Blades are t 2–15 cm, slightly flattened erect stems can grow 1–30 cm tall. The seed heads in a cluster of two to six spikes together at the top of the stem, each spike 2–5 cm long.
15. Egyptian crowfoot grass, (*Dactyloctenium aegypticum)* Poaceae, Annual herb,Culms up to 50 cm. long up to five nodded , internodes cylindrical, , Spikelet 4 mm long, strongly compressed, ovate, solitary, sessile, patent alternately left and right on the ventralside of the; dense, forming a very flat comb.
16. Chikua, Feather finger grass, feathery Rhodes-grass and feather wind mill grass.(*Cloris virgata*) , Poaceae, Annual herb, 50 cm tall, spread via stolen. The inflorescence is an arrayof 4 to 20 fingerlike branches up to 10 centimeters long. Each branch contains approximately 10 spikelet's per centimeter. Each spikelet has one fertile floret and one or two sterile florets.
17 Garu Job's tears (*Coix aquatic*) Poaceae perennial aquatic herb., Stems creeping and rooting from nodes at base, sometimes floating, up to 30 m long, Leaf sheaths are smooth,hairless or upper sheaths hispid. Leaves are narrowly to broadly linear, up to 1 m long, and 1-2.5 cm wide, hispid with tubercle-based hairs on both sides.
18 Guria grass, red false beard grass, and reddish-yellow beard grass, (*Crysopogon fultrus*), Poaceae Annual herb, Culms densely tufted, geniculation, to 50 cm. Leaf-blades flat, 2-6 x0.2-0.4 cm, hairy along margins; ligule to 0.05 cm. Panicles ovate, to 7 cm. Sessile spikelet: lower glume to 0.45 cm, folded, hispid at apex; upper glume to 0.45 cm.
19 Ludiiadan Buffel grass, (*Cenchrus cilliaris L*) Poaceae, tussock-forming perennial grass,Submerged rhizomatous, The culms are erect or decumbent, reaching up to 2 m in lengthare linear blades, green to bluish green, slightly filose, 3-30 cm long and 4-10 mm wide.Inflorescence is a spike-like panicle, bearing deciduous spikelet which are surrounded by hairybristles.. The seed is an ovoid caryopsis14-2 mm long..
20 Sirki Giant Reed Reed grass (*Arundinela setosa*), Poaceae annual herb culms tufted, 20-40 cm high; nodes glabrous. Leaves 3-10 x 0.5 cm, lanceolate; rounded at base, densely hairy; sheath rounded, hairy; ligule a fimbriate membrane. Panicle 5-20 cm long; effuse, branches scabrid. Spikelets 6 x 2 mm, glabrous;
21 Sirki , Niddle grass, (*Arissttida adsensins*) , Poaceae short-lived but perennial , The culms are thin, erect or geniculate, stiff, simple or branching at the lower nodes, yellow tobright green in color, becoming straw colored when matured. leaves are linear, narrow, up to 20 cm long. The seed-heads are purplish with spikelets densely clustered on the branches. The spikelets are covered with three unequal, scabrous and 1-2.5 cm long awns
22 Lesser bulrush, narrow leaf cattail or lesser reed mace (*Typha anguistifolia*), Typhaceae:Perennial herb, Tall emergent, Marshy or aquatic, leaves 1m. long, inflorescence- struttedspike, redish brown, male and female separated by interval.

CONCLUSION

1. There are 4 points of hot water springs at HWST having temp. 85^{0}C, 70^{0}C, 60^{0}C and42^{0}C at distance of 2-3 meters.
2. There is much more presence of sulfate salts in the water of HWST and its pH is 8.5 .
3. There are presence of Biodiversity of microbes in HWST and 22 angiosperms in thelale made by effluent of HWST.

There is possibility of application geo hydro thermal energy of HWST to establishpower generation plant.

REFERENCES

[1] https://www.indiatoday.in/education- today/gk-current-affairs/story/7-top-hot-water-springs-of-india- 1381626-2018-11-22. Retrieved on 10-01-2022

[2] http://timesofindia.indiatimes.com/articleshow/9169398.cms?utm_ source=contentofinterest&utmmedium=text&utm_campaign=cppstRetrieved on 10-01-2022.

[3] Sergio Guajardo-LeivaFernando Santos, Oscar Salgado, Christophe Regeard, Laurent Quillet, and Beatriz Díez :Unveiling Ecological and Genetic Novelty within Lytic and Lysogenic Viral Communities of Hot Spring Phototrophic Microbial Mats,American Society of Microbiology ASM- Journal 17 November 2021 https://journals.asm.org/doi/10.1128/Spectrum.00694-21. Retrieved on 10-01-2022

[4] https://www.longdom.org/peer-reviewed-journals/geothermal-energy-29446.html. Retrieved on 10-012022

[5] https://iopscience.iop.org/article/10.1088/1748-9326/6/3/034023 Retrieved on 10-01-2022

[6] Gouri Shankar Mishra[1], William E Glassley[2] and Sonia Yeh[1] Realizing the geothermal electricity potential—water use and consequences; IOP Publishing Ltd.Environmental Research Letters, Volume 6, Number 3pp 220-226.(2000)

[7] K. M. Lawal, B.F. Sule and A.O. Ogunlela'Economic Sustainability of IntegratedHydropower Development of Ero-Omola Falls, Kwara State, Nigeria. "AMSE JOURNALS –2014-Series: Modeling D; Vol. 35; N° 1; pp 24-51 (July 15, 2014)

[8] https://amsemodelling.com/publications/modelling_measurement_and_control/Production_Engineering_and_ Management_Organization_Human_and_Socia_Problems/35%20vol1/Economicsustainability_of_integrated_hydro power_development_of_EroOmola_Falls_ Kwara_state_Nigeria.pdf. Retrieved on 15-04-2022

[9] Jack D. Farmer; 'Hydrothermal Systems: Doorways to Early Biosphere Evolution Hydrothermal Systems: Doorways to Early Biosphere Evolution' GSA TODAY APublication of the Geological Society of America. Vol. 10, No. 7 July 2000
https://asmedigitalcollection.asme.org/energyresources/article/121/4/295/406141/Retrofitting-a- Geothermal-Power-Plant-to-Optimize. Retrieved on 15-04-2022

[10] M. Kanogˇlu, Y. A. C¸engel; ' Retrofitting a Geothermal Power Plant to OptimizePerformance: A Case Study "AMSE Journal digital collection *J. Energy Resour. Technol*. Dec 1999, 121(4): 295-301 December 1, 1999, https://doi.org/10.1115/1.2795996
https://asmedigitalcollection.asme.org/energyresources/article/121/4/295/406141/Retrofitting-a-Geothermal-Power-Plant-to-Optimize. Retrieved on 15-04-2022

[11] Xiaocui Wang and Xun Zhou; " Hot Springs in Yunlong County of Yunnan inSouthwest China" Hindavi ; Geofluid; Volume 2019 |Article ID 8432496 | https://doi.org/10.1155/2019/8432496Volume 2019 |Article (March 2019)
https://www.hindawi.com/journals/geofluids/2019/8432496/ Retrieved on 15-04-2022

[12]. Robin W Renaut and Brian Jones; "Sedimentology of hot spring systems AMSEDigitalCollection Canadian Journal of Earth Sciences 40(11):1439—1442; February 2011 DOI:10.1139/e03-085
https://www.researchgate.net/publication/237169171_Sedimentology_of_hot_spring_systems Retrieved on 10-01-2022

[13] Ou Bai,, Masatoshi Nakamura, Yasuyuki Ikegami, Haruo Uehara; 'A Simulation Model for Hot Spring Thermal Energy Conversion Plant With Working Fluid of Binary Mixtures '*J. AMSE digital Collection Eng. Gas Turbines Power*. Jul2004, 126(3): 445- 454 . August 11, 2004 https://doi.org/10.1115/1.1760526
https://asmedigitalcollection.asme.org/gasturbinespower/article-abstract/126/3/445/463738/A-Simulation-Model-for-Hot-Spring-Thermal-Energy?redirectedFrom=fulltext Retrieved on 16-4-2022

[14] AMSE Journals:
https://amsemodelling.com/publications/modelling_measurement_and_control/Production_Egineering_and_ Management_Organization_Human_and_Socia_Problems/35%20vol1/Economicsustainability_of_integrated hydropower_development_of_EroOmola_Falls_Kwara_state_Niger ia.pdf Retrieved on 16-4-2022

[15] Alexander Richter; " Hot Springs on the river bed at Tattapani, India (source flickr/ Gopal Venkatesan, creative commons) " 22 Aug 2017.
https://www.thinkgeoenergy.com/tatapani-geothermal-project-in-india-will-see-drilling-start-soon/ Retrieved on 16-4-2022

[16] https://timesofindia.indiatimes.com/india/nations-first-geo-thermal-power-project-in-chhattisgarh/articleshow/22384605.cms Retrieved on 16-4-2022

[17] https://www.livemint.com/Industry/JNrZIASEc8TsDbUO3fGkuL/Indias- first-geothermal- plant-to-come-up-Chhattisgarh.html. Retrieved on 16-06-2022.

[18] https://thermalpower.industry-focus.net/chhattisgarh-thermal-projects/582-ntpc-to- develop-tattapani- geothermal-power-plant-ntpc-to-develop-tattapani-geothermal-power- plant.html .
Retrieved on 16-06-2022.

[19] https://www.bhaskar.com/news/CHH-RAI-HMU-tatapani-thermal-power-project-news- hindi-5380483- PHO.html. Retrieved on 16-06-2022.

[20] Frank, K.D. and Knudsen, Delno, "G89-901 Understand Your Soil Test: Sulfur" (1989). Nebraska Cooperative Extension G89-90 *Historical Materials from University of Nebraska-Lincoln Extension*. Paper 1356. (Electronic version revised August 2000)

[21] Loudon, J C "Encyclopedia of Plants'A Falcon Book from Cosmo Publication New Delhi India.Vol.1 Part A ,pp 660-780 (1989)

[22] Naik, M. L. and Mishra R. P. ; " Floral Diversity of Chhatisgarh" CG Biodiversityboard, first flore ,Aranya Bhawan , sector 19, New Raipur CG India. pp: 108- 184.(May 2021)

[23] Mahar, H.D.; Mahar, R.B. "Geophysical and hydrological parameters of an opposite flowof water 'Ultapani' at Bisarpani, Kamaleshwarpur, Mainpat Plateau Surguja CG, India." Modeling, Measurement and Control C, Vol. 80, No. 2-4, pp. 44-49. (2019). https://www.iieta.org/journals/mmc_c/paper/10.18280/mmc_c.802-402

[24] Mahar, H.D. (2019). Modeling and simulation of geo-thermal electricity to probe the volcano-seismic prediction. Modeling, Measurement and Control C, Vol. 80, No. 2-4,pp. 37-43.

https://www.iieta.org/journals/mmc_c/paper/10.18280/mmc_c.802-401.
[25] Alexander Richter; "Hot Springs on the river bed at Tattapani, India (source: flickr/ Gopal Venkatesan, creative commons) " 22 Aug 2017 https://www.thinkgeoenergy.com/tatapani-geothermal-project-in-india-will-see-drilling-start-soon/ Retrieved on 16/03/2022.
[26] https://timesofindia.indiatimes.com/india/nations-first-geo-thermal-power-project-in-chhattisgarh/articleshow/22384605.cms. Retrieved on 16-06-2022.
[27] https://www.livemint.com/Industry/JNrZIASEc8TsDbUO3fGkuL/Indias-first-geothermal- plant-to-come-up-Chhattisgarh.html, Retrieved on 16-06-2022.
[28] https://thermalpower.industry-focus.net/chhattisgarh-thermal-projects/582-ntpc-to- develop-tattapani- geothermal-power-plant-ntpc-to-develop-tattapani-geothermal-power- plant.html. Retrieved on 16-06-2022.
[29] Danik Bhaskarhttps://www.bhaskar.com/news/CHH-RAI-HMU-tatapani-thermal-power-project-news- hindi-5380483-PHO.htmhttps://www.bhaskar.com/news/CHH-RAI-HMU-tatapani-thermal-power-project- news-hindi-5380483-PHO.htm. Retrieved on 16-06-2022.
[30] Stevan Earle; Creative Attribution 4.0 International License, Physical Geology, The Temperature of Earth's Interior; BC Campus Open Publish: Retrieved on 16-06-2022.