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Physico-Chemical and Biological Studies of Euthermal Sulphur and Chliarothermal Springs Lakki Shah Saddar (District Dadu) Sindh, Pakistan

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Abstract: Physico-chemical and biological study of three springs were carried out, which are located on the Lakki hills, near Lakki Shah Saddar Railway station, District Dadu. Two of these are euthermal (40-42°C) with significant evolution of hydrogen sulphide (135-152 mg/L) with high electrical conductivity 13000-14300 μS/cm mostly because of sodium chloride and pH 6.35-6.85 at the source. The third spring is chliarothermal having water temperature of 18-30°C and is a fresh water spring and forms seepage pool with pH 7.15, total dissolved solids (TDS) 1088 mg/L and electrical conductivity 1700μS/cm. The study revealed the occurrence of 43 spp. of *Cyanophyta*, 25 spp. *Chlorophyta* & 5 spp. *Bacillarophyta* in all the three springs, *Chara zeylanica* was present in fresh water spring, *Lamprothamnium succinctum*, *Phragmites communis*, *Typha domingensis* along with zooplankton, insects, Mollusca and Fishes, *Barbus tictio* were found present at the end of the channel of the two hot springs.

Key words: Water quality, flora and fauna of Lakki springs.

Introduction

There are a series of Lakki springs located in Lakki hills of Khirthar range, near Lakki village, about 85 km north west of Hyderabad (Sheet No.35 N/15, Lat. 26.16'. Long. 67.55') and 150 feet above sea level. The area is dry and arid. The Lakki hot springs are known since long for the cure of certain diseases. Though a number of people visit Lakki hot springs every year, but a little work has been reported. From this laboratory two hot springs classified as euthermal have been reported to contain significant amount of chloride ion with bicarbonate type alkalinity and sulphide ions (Khuhawar *et al.*, 1986). Flora of the two spring have also been reported (Leghari and Thebo, 1983). Khan and Husini (1987) reported geochemical studies of some springs of Sindh. Recently Khuhawar and Lanjwani (1998) have reported the presence of uranium in the hot springs.

This investigation reports the presence of third spring at about 2 km south west of hot springs and examines the physico-chemical and survey of flora and fauna in all the three springs located at Lakki hills.

Materials and Methods

Two hot spring were labeled as main spring 1 and relatively smaller as spring 2. The main spring 1 forms a pool of about 20 x 12 feet with depth of 2 to 3 feet. Air bubbles were seen coming out of the surface of water with a strong pungent hydrogen sulphide smell. The water from the pool flows in the form of stream, which falls down the hills slowly and gradually disappears in the rocky bed during travel of about 2-3 km.

The spring 2 is at distance of about 200 m north from main spring 1 and also appears as a pool of about 14 x 8 feet with a depth of about 1 to 1.5 feet. The rate of air bubbles, and the smell of hydrogen sulphide were less intense than main spring 1. The smaller spring 2 also flow in the form of stream and joins with the main flow of the main spring 1.

Spring 3 is located 2-3 km in the north away from the main hot spring I within the same valley and appears as a small pool of about 2 x 2 feet with a depth of about 0.5 feet. The water is used for drinking by wildlife, domestic animals and the human living in the area.

A water sample from each of the spring was collected in clean 1.5 L plastic bottle, rinsed several time before filling completely with water sample. The samples were collected from the middle of each pool, from the surface within the depth of 3 to 6 inches. The temperature of water and air were noted. Conductivity and salinity were measured with WTW 320 conductivity meter on the spot. The water samples for chemical analysis were examined in the laboratory quickly. pH was measured with Orbn 420 A pH meter, chloride, alkalinity and hardness were determined by titration with standard silver nitrate, hydrochloric acid and E.D.T.A respectively (APHA, 1981). Sulphide was estimated by iodometric titration. Nitrate, phosphate and silicate were determined by spectrophotometry using Hitachi 220 spectrophotometer. Nitrate was determined using brucine sulphate as derivatizing reagent. Total hydrolyzable phosphate was determined by persulphate digestion method followed by reducing phosphomolybodic acid formed with ascorbic acid to molybdenum blue. Sulphate was determined by turbidimetric method as barium sulphate. Sodium, potassium, calcium and magnesium were determined by air-acetylene flame with Varian Spectra AA-20 atomic absorption spectrometer at 589 nm, 766.5 nm, 422.7 nm and 485.7 nm. The analyses were carried out in triplicate with integration time 3 seconds and delay time 3 seconds (Alen, 1989).

Flow rate of the main spring 1 and a smaller spring 2 was calculated from the relation.

$$Q = \{(B \times D) \times S/T\}$$

Where Q = Quantity ,B = Breath and D = Depth of drain. S = specific length of drain and T = Time interval for travel of S distance by water.

All the biological samples were collected by plankton net # 25 μm, hand nets and by hand picking methods. The samples were preserved in 3% G.R. grade formaldehyde (E. Merek) and identified with the help of taxonomic keys of Prescott (1962), Desikachery (1959) for the algae and higher aquatic plant (Angiospermic) and for fishes (Mirza, 1990).

Results and Discussion

The results of chemical analysis are summarized in Table 1. The main spring 1 and smaller spring 2 continues to maintain water temperatures of 42 and 40°C as reported by (Baker & Maclagen, 1844; Khuhawar *et al.*, 1986). The spring 3 indicated considerably lower temperature 33°C and having

Table 1: Water Analysis Samples from Lakki Shah Saddar Hot and Cold Springs District, Dadu, Sindh, Pakistan

Parameters	Date of Collection of Samples						
	5-5-1999			1982-1983		1984.00	
	0	1	2	1	2	1	2
Temperature of water in °C	33.00	42.00	40.00	42.00	40.00	42.00	40.00
Temperature of air in °C	42.00	44.00	44.50	34.40	34.00	-	-
pH	7.15	6.35	6.85	6.63	6.80	6.75	6.68
Conductivity in μS/cm	1700.00	14300.00	13000.00	7288.00	3857.00	-	-
Chloride in mg/L	106.00	4254.00	35.45	3628.00	3519.00	3586.00	3426.00
M. Alkalinity as $CaCo_3$ in mg/L	90.00	260.00	260.00	-	-	-	-
Hardness as $CaCo_3$ in mg/L	530.00	680.00	430.00	835.00	821.00	1106.00	1080.00
Acid Hydrolyzable phosphate in mg/L	0.23	0.08	0.28	-	-	-	-
Sulphate in mg/L	180.00	210.00	187.00	-	-	-	-
Sulphide in mg/L	-	148.00	130.00	152.00	135.00	-	-
Silica in μg/L	3.00	10.00	11.00	-	-	-	-
Nitrate in mg/L	2.70	0.00	0.00	-	-	-	-
Sodium in mg/L	94.00	2383.00	2173.00	-	-	1106.00	1080.00
Potassium in mg/L	20.00	42.00	36.00	-	-	54.00	40.00
Calcium in mg/L	225.00	346.00	350.00	-	-	328.00	352.00
Magnesium in mg/L	88.00	288.00	250.00	-	-	286.00	255.00

Sampling Stations

0. Spring chliarothermal (3), 2 km away from main (1) hot spring.
1. Main spring near Rest House (1)
2. Second spring 50 m away from Rest House (2).

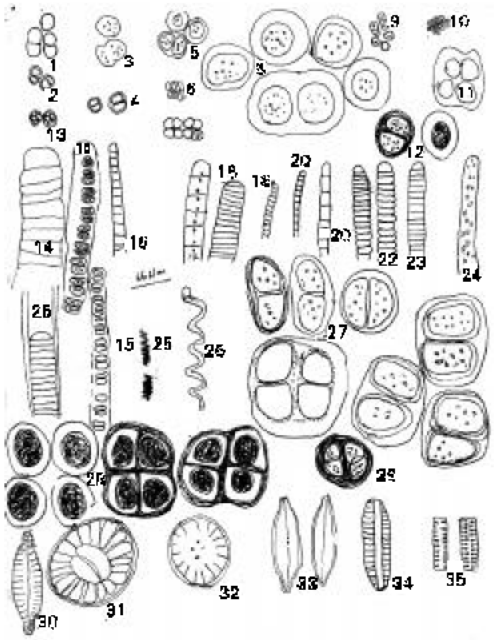
Table 2: Distribution of Flora and Fauna at Sulphur Hot Spring at Lakki Shah Saddar District Dadu, Sindh Pakistan

S. No.	Name of species		Spring 42-40°C	Spring 40-35°C	Tail 35-30°C
			1.00	2	3.00
1.	*Aphanocapsa thermalis* (Kutz) Brugg.		++	++	+++
2.	*Aphanocapsa gravillei* Rab		-	+	++
3.	*Aphanothece bullosa* (Menegh) Raben	+	+	++	
4.	*Chrococcus limneticus* Lemm	-	-	++	
5.	*C. montanus* Hansg.		-	-	++
6.	*C. macrococcus* (Kutz) Rab	+	+	++	
7.	*C. dispersus* Lemm	-	-	++	
8.	*C. minor* (Kutz) Nag	+	+	++	
9.	*C. tenax* (Kirch) Hieron		+	+	++
10.	*C. turgidus v. maximus* Nyggard		+	+	++
11.	*Coelosphaerium* Kuetzingianum Nag		-	-	++
12.	*Gloeocapsa gelatinosa* Kutz		+	+	++
13.	*Gloeocapsa calcarea* Tilden		+	+	++
14.	*Merismopedia elegan* A. Br.		-	+	++
15.	*M. glauca* (Eh.) Nag.		-	-	++
16.	*M. thermalis* Kutz		++	++	+++
17.	*Gomphosphaeria aponina* Kutz	-	-	++	
18.	*Johannes baptistia pellucida* (Dicke) Taylor		+	++	+
19.	*Synechococcus elongatus* Nag	++	+	+	
20.	*Synechocystis aquatilis* Sauv.	+	+	++	
21.	*Synechocystis salina* Wislouch	+	+	++	
22.	*Oscillatoria chalybea* (Mer) Gom		-	+	+
23.	*O. jasorvensis* Vauck		-	++	-
24.	*O. limosa* Ag		+	++	++
25.	*Phormidium tenue* Gomont		+	+	++
26.	*P. autumnale* (Ag) Gom		+	+	-
27.	*Phormidium* spp.		-	++	-
28.	*Sprulina labyrinthiformis* (Meneg) Gom	++	++	+	
29.	*S. laxa* Smith		+	++	+
30.	*S. subsalsa* Oerstd	+	++	+	
31.	*S. laxissima* West		+	++	+
32.	*S. major* Kutz		-	+	+
33.	*Scytonema* spp.		-	+	+
34.	*Cylindro spermum* stagnale	-	++	+	
35.	*Homoeothrix fusca*	-	++	+	
36.	*Dermocarpa olivaceae* Tilden	-	+	++	
37.	*Nostoc* spp.		-	+	+
38.	*Anabaena* spp.		-	+	+
39.	*Calothrix thermalis* (Sch) Hansgirg		-	-	++
40.	*Calothrix* spp.		-	-	++
41.	*Nostoc spongi forme* Ag		-	++	++

42.	*Cylindrospermum muscicola* Kutz		-	-	++
43.	*Cylindrospermum stagnale Kutz*	-	+	+	
44.	*Lyngby hierony musii* Lemm.	-	++	++	
45.	*L. tylori*		-	+	++
46.	*L. major* Menegh		-	+	+
47.	*L. martensiana* (Harv) Menegh	-	+	+	
48.	*L. spiralis* Gietler		-	+	+
49.	*Oscillatoria okeni* Ag	+	++	+	
50.	*O. princeps* Vaucher	-	+	++	
51.	*O. salina* Biswas		-	++	++
52.	*O. tenuis* Ag		-	++	++
53.	*O. amphigranulata*	-	-	+	
54.	*O. subbreveis* Schmiddle		-	+	+
55.	*O. formosa* Bory		-	++	++
56.	*O. angusta* Koppe		-	++	++
57.	*O. terebriformis* (Ag,) Elenk		-	++	++
58.	*Oscillatoria willei* Gardner		-	+	++
Chlorophyta					
1.	*Mougeotia sphaerocarpa*		-	++	-
2.	*Mougeotia* spp-II		-	+	+
3.	*Spirogyra micropunctata* Transu	-	+	+	
4.	*Spirogyra subsalsa* Kutz		-	-	++
5.	*Spirogyra fluellbornei* Sch.		-	-	++
6.	*Zygnema* spp-I		-	-	+
7*.	*Scenedesmus dimorphus* (Turp) Kuetz	-	-	+	
8*.	*Scenedesmus arcuatus* lemm	-	++	+	
9*.	*Cosmarium undulatum*		-	+	+
10*.	*Cosmarium tenue* Arch		-	+	+
11*.	*Cosmarium granatum* Breb		-	+	+
12*.	*Stigeoclonium tenue*	-	++	-	
13*.	*Rhizoclonium* spp.	-	+	-	
14*.	*Lamprothamnium succinctum* (A Br.) R.D.Wood		-	++	-
15*.	*Chara zyelanica*		-	+	+
16.	*Oedogonium* spp.		-	-	+
17.	*Kircheneriella* obesa		-	-	+
18.	*Scenedesmus bujugatus* (Turp) Kuetz	-	-	+	
19*.	*Selenastrum westii* Smith		-	-	+
20*.	*Uronema* spp.		-	-	+
21*.	*Cosmarium* cf. *formosulum* Hoff.		-	-	+
22*.	*Cosmarium laeve* Rab		-	-	+
23*.	*Cosmarium laeve var. reniforme* Hairnon	-	-	+	
24*.	*Phacus acuminatus* Stokes		-	+	+
25*.	*Euglena* spp.		-	+	+
Algal Flora of Chliarothermal (TEPID) Spring near Lakki Hot Spring					
1.	*Mougeotia* viridis		-	+	-
2.	*Spirogyra fluellebornei*		-	++	-
3.	*Oedogonium* spp.		-	+	-
4.	*Kircheneriella obesa*		-	+	-
5.	*Nematoda* spp.		-	++	-
6.	*Oscillatoria* spp.		-	+	-
7.	*Oscillatoria chalybea* (Mertens) Gomant	-	++	-	
8.	*Oscillatoria willei Gardner em.* Drouet		-	+	-
9.	*Chrococcus minutus* (Kuetz) Ag.		-	++	-
10.	*Johannesbaptistia pellucida* (Dickie) Taylor		-	+	-
11.	*Gloeocapsa livida* (Carm.) Kuetz		-	+	-
12.	*Merismopedia tenuissima* lemm	-	++	-	
13.	*Synechococcus aeruginosus* Nag		-	++	-
14.	*Scenedesmus dimorphus* (Turp) Kuetz	-	++	-	
15.	*Scenedesmus bijugatus (*Turp) Kuetz		-	++	-
16*.	*Selenastrum westii* G.M. Smith	-	+	-	
17.	*Spirogyra subsalse* Kuetz		-	++	-
18.	*Chara zeylinca*		-	+	-
19.	*Uronema* spp.		-	+	-
20.	*Fungal spore*		-	+	-
21.	*Cosmarium undulatum f. minor* W.et G.S. West		-	+	-
22.&23.	*Cosmarium cf. formosulum* Hoffmann		-	+	-
24.	*Cosmarium laeve* Rabenhorst	-	+	-	
25.	*Cosmarium laeve* Rabenhorst	-	+	-	
26.	*Cosmarium laeve var. reinforme* Hiarano	-	+	-	
27.	*Phacus acuminatus*	-	+	-	
28.	*Phacus acuminatus stokes*		-	++	-

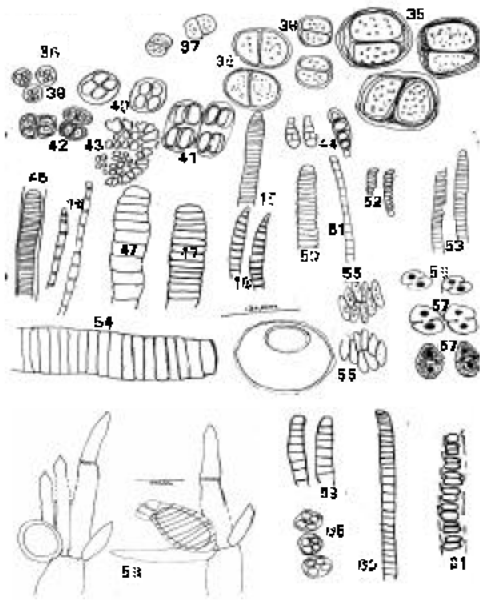
29.	*Phacus cf. obolus* Pochm	-	+	-
30.	*Phacus undulatus* (Skv.) Pochm	-	+	-
31.	*Euglena* spp.	-	+	-
32.	*Lacanes* spp.	-	++	-

Note: - Absent, + rarely present, + + often present, + + + dominant, * newv repots.



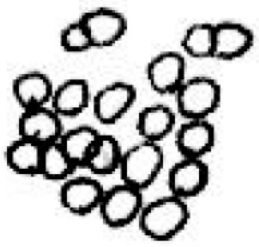
Lakki Shah Saddar District Dadu Fig. No.1-35

1. *Aphanothece castageni* (Breb) Rab.
2., 4 & 13. *Aphanocapsa biformis*
3. *Gloeocapsa* spp.
6-7. *Chroococcus montanus* Hansg.
8 &11. *Chroococcus tenax* (Kirch) Hie.
9. *Synechococcus aeruginossus* Nag.
10. *Aphanocapsa* spp.
12. & 29. *Chroococcus turgidus var. maximus* Nyg
14. *Oscillatoria subcapitata* Ponomarenko
15. *Johannesbaptistia pellucida* (Dickie) Taylor
16. *Oscillatoria angustissima* West G.S.
17. *Oscillatoria cf amphigranulata*
18. *Oscillatoria limosa* Ag.
19-20. *Phoronidum fragile* (Menegh) Gom.
21-22. *Oscillitoria chalybaea* Gom.
23. *Oscillatoria simplicissima.*
24. *Oscillatoria guttulata* Vangor.
25. *Lyngbya hierony* musii Lemm.
26. *Spirulina laxissima* West, G.S.
27. *Chroococcus turgidus* (Kutz) Nag.
28. *Chroococcus giganteus* West. W.
30. *Navicula* Spp.
31. *Campylodiscus* Spp.
32. *Cyclotella Kutzingiana* Thw.
33. *Navicula* Spp.
34. *Amphora ovalis.*
35. *Eunotia arcus* Eh.

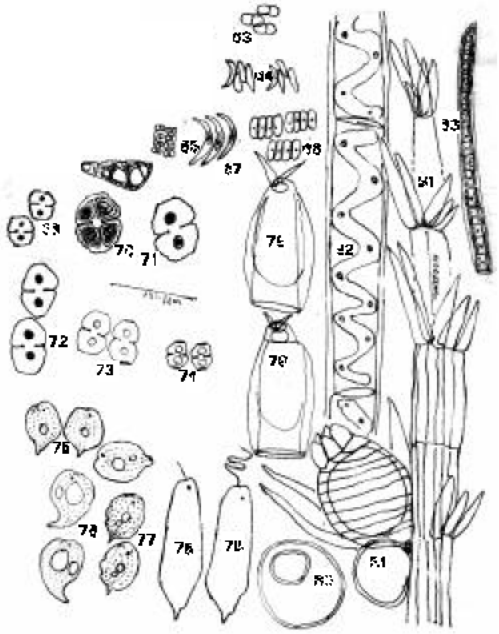


Lakki Shah Saddar District Dadu Fig. 36-61

36. *Chroococcus pituminosus* (Bory) Hansg.
37-38. *Gloeocapsa turgida* (Kutz) Hlle
34. *Merismopedia tenuissima* lemm.
39. *Chroococcus turgida f. doricensis* (Nag) Hansgirg.
40. *Gloeocapsa crepidinum* Thruet.
40-42. *Chroococcus turgidus f. submiba* (Haus) Hollerb.
42-43. *Gloeocapsa punctata* Nag.
44. *Chroococcus limneticus* lemm.
45. *Gloeocapsa montana* Kutz.
46. *Gomphosphaeria aponina* Kutz.
47. *Fungal spores.*
48. *Lyngbya confervoides* A.G.
49. *Oscillatoria* Spp.
50-51. *Oscillatoria oranta* Kutz.
52. *Oscillatoria sancta* (Kutz) Gom.
53. *Oscillatoria limosa* Ag.
54. *Oscillatoria geitleriana* Elenk.
55. *Spirulina labyrinthiformis* (Menegh) Gom.
56. *Oscillatoria okeni* Ag.
57. *Oscillatoria princeps* Vauchr.
58. *Scenedesmus arcuatus* Lemm.
59. *Cosmarium tenue* Arch.
60. *Cosmarium granatum* Breb.
61. *Difflugia globulosa* Duji.



Lakki Shah Saddar District Dadu Fig.62
62. *Lamprothamnium succinctum* (A.Br) R.D.W.



Lakki Shah Saddar Cold Spring (Clairothermal), District Dadu Fig.63-85.

63. *Oscillatoria chalybea* Mertens.
64. *Oscillatoria formosa* Bory.
65. *Johannosbaptistia pallucida* (Dick) Taylor.
66. *Aphanocapsa* spp.
67. *Synechococcus aeruginosus* Naeg
68. *Scenedesmus incrassatulus* Bohlin.
69. *Chroococcus minor* (Kuetz) Naeg.
70. *Merismopedia elegans*.
71. *Scenedesmus bijuga* (Turp) Lageri.
72 *Cosmarium reaticum* Messik
73. *Cosmarium subimpresulum* Borge.
74. *Cosmarium* spp.
75-76. *Cosmarium leave* Rab. Var leave.
77. *Phacus orbicularis*
78. *Phacus* spp.
79. *Phacus uniguis* Pochm.
80. *Euglena geniculata* Duji.
81. *Lecane cf. papuana* (Murray).
82. *Difflugia globulosa* Duji.
83. *Chara zeylanica*
84. *Spirogyra* spp.
85. *Uronema confervicolum* lagerheim.

dominant flora consisting of *Chara zeylanica, Spirogyra* Spp. *Desmidis, Phacus* & *Euglena* (Figs. 68-78) species to Chlorophyta (Table 2). Spring 1 and 2 indicated high conductivity, TDS, chloride and sodium. This leads to suggest that main spring 1 and smaller spring 2 contained significant amount of sodium chloride and confirms the presence of hydrogen sulphide (Table 1).

The spring 3 did not indicate the presence of hydrogen sulphide and contained a significant amount of less dissolved solids with conductivity of 1700 μS/cm and TDS 1088 mg/L. The water contained higher calcium in concentration than sodium. The observed pH 7.15 was acceptable for the consumption for animals and humans (Table 1).

The flow rate of the main spring 1 and smaller spring 2 was calculated to 87 and 30 gallons/hour, but there was no flow in spring 3 and it maintained a level in the water pool.

In the Lakki hot springs 1 & 2 where water oozes out with hydrogen sulphide and having temperature 40-42°C indicated dominant growth of Sulphur bacteria and Cyanophyta, such as *Spirulina* spp. *Phormidium* spp. *Lyngbya* spp., and *Chroococcus* (Figs. 1-28). Some of *Bacillariophyta, Navicula, Cyclotella* and *Amphora, Eunotia, Campphylodiscus* species were also found(Figs. 30-35). At the source the dissolved oxygen was absent due to the presence of hydrogen sulphide. The spring water have pH value of 6.35 at the source. Sulphide is oxidized into the rapid falls with gradual increase of pH value and reached up to 8.5 about 3 km from the source. Castenholz and Wickstorm (1975) observed that dissolved sulphide above 0.2 mg/L effects on biological life. It is confirmed that only species of *Cyanophyta, Bacillariophyta* and *Sulfur bacteria* were found present in the main spring 1 & 2 along with the presence of *Eristalis larvae* because of its air breathing ability. The result agreed with Castenholz (1973) Jana and Sarkar (1971, 1972).

As water flows in the form of channels and eventually water of both 1 & 2 falls down the hills together with the loss hydrogen sulphide (H_2S) during the travel because of volatilization and oxidation by mixing with air. The water also cools down to atmospheric temperature. The results indicate a zone of *Oscillatoria* spp. *Phormidium* spp. and *Lyngbya* spp. where *Oscillatoria princeps* Voucher (Figs.36-61) was found dominant. On the submerged rocky bottom *Chroococcus* spp. *Aphanothece* spp, *Aphanocapsa* spp. along with the *Chironomus*, and Masqueto larva together with Beetles were found.

The water eventually spread on the surface of calcareous rocky ground and develop small polls where *Mougeotia* spp., *Spirogyra* spp, *Scenedesmus* spp., *Kirchneriella, Pediastrum* spp., *Phacus* spp., and *Euglena* spp. of Chlorophyta (Figs.14-31) and *Merismopedia* spp., *Chroococcus* spp., *Gomphosphaeria* spp., *Oscillatoria* spp., *Johannesbaptistia* spp. and *Lyngbya* spp. were found in Planktonic forms in the channels and pools. Where as *Stigeoclonium tenue Rhizoclonium* spp, *Cladophora glomerata, Gloeocapsa* spp., *Aphanocapsa* spp., *Homoeothrix* spp. and *Ulothrix* spp. were found epilithic on the submerged stones (Fig.63-85).

Lamprothamnium succinctum (Fig.62), *Typha domingensis, Phragmites communis* and grasses were present in the channel along with zooplankton, insecta, mollusos and some fishes such as *Punctius ticto* (Ham.) and Torputitora (Ham.) were observed the end of channel with water temperature 30-35°C.

Chlorophyta, Spermatophyta were absent at the source of the spring 1 & 2, due to the high temperature and hydrogen

sulphide (H_2S), but the species were observed down the channel having the temperature 30-37°C.

The work reports the physico-chemical, Flora and fauna of three natural springs located in Lakki hills and confirms the presence of hydrogen sulphide in two springs with sodium chloride salinity and sodium carbonate akalinity. The flow of water was calculated to 87 and 30 gallons /hrs. Cynophyta and Bacillarophyta are dominant flora through out the Springs.

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Reference

Abu Bakar, M., 1965. Thermal Springs of Pakistan. Rec. Geol. Surv. of Pakistan, pp: 16: 1-3.

Alen, S.E., 1989. Chemical Analysis of Ecological Materials, Backwell Scientific Publication, Second Ed. Oxford.

APHA., 1981. Standard methods for examination of water and waste water 15th edition. Washington D.C.

Baker, W.E. and C.A. Maclagen, 1848. Thermal springs of Sindh. J. Asiatic Soc. Bengal, 17:230.

Beg, M.A.A., S. N. Mahmood and S. Naeem, 1984. Characterization of waters. Part-I. Spring waters in and around Karachi. Pak. J. Sci. Ind. Res., 27:131-136.

Castenholz, R.W. and C.E. Wickstorm., 1975. Thermal streams, pp 265-285. In River Ecology edited by B.A. Whiton, Blackwell, London.

Castenholz, R.W. , 1973. The possible photosynthetic use of sulfide by the filamentous photo tropic bacteria of hot springs. Limnol. Oceanogr, 18: 853-876.

Desikachary, T.V., 1959. Cyanophyta 1-686 PP . I.C.A.R., New Delhi.

Jana, B. and H. L. Sarkar., 1972. The Hydrobiology of selected thermal springs of Raj-gar Bihar. J. Asiatic Soc., 14:60-69.

Jana, B. and H. L. Sarkar, 1971. The limnology of Swetganga-A thermal spring of Bakreswar, West Bengal India. Hydrobiologia, 37:33-47.

Khan. I.A. and S.M. Husini, 1987 Geochemical study of some Thermal Springs of Sindh, Pakistan. Pak. J. Sci. Ind. Res., 30:649-653.

Khuhawar, M.Y and S.N. Lanjwani, 1998. Liquid chromatographic determination of uranium in Lakki hot springs using Bis (Salicylaldehyde) propylenediimine as derivatizing reagent. Jour. Chem. Soc. Pak., 20:204-208.

Khuhawar, M.Y., S.N. Thebo and S.M. Leghari, 1986. Physico-chemistry investigations of hot Lakki springs of Sindh, Pakistan. Physical Chem. J., .5:43-49.

Leghari, S M and, S.N Thebo, 1983. Cyanophyceae of hot spring at Lakki Shah Saddar Sindh. Pakistan. Sindh Univ. Res. J., (Sci. Ser), 15:147-150.

Mirza, M.R., 1990. Fresh Water fishes of Pakistan. Urdu Science Board Lahore, pp : 128.

Prescott, G.W., 1962. Algae of the Western Grate Lakes area. W. M. C. Brown Co. Publisher, Dbuque , Iowa, pp: 997.