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Current scenario of limnological characteristics of Pushkar lake, Rajasthan, India

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Abstract

Lakes are a unique entity, where physical, historical, cultural, social, administrative, or functional elements come together to create a tourist reality that is both spatial and practical. For locals, lakes and reservoirs in dry and semi-arid environments are a major source of water. In recent decades, there has been concern about how people interact with water bodies. All tourist activities in the town of Pushkar depend on Pushkar Lake. The lake experiences an increase in biochemical oxygen demand (BOD), alkalinity, water hardness, chlorine, fluoride, and nitrate levels as a result of the millions of people who bathe there and participate in other religious activities almost all year long. Samples were gathered in PET bottles using conventional methods. To estimate the quality of drinking water, Horton's Water Quality Index (WQI) was used. All of the analysis techniques adhered to the prescribed protocols as per the techniques described in APHA. This research reveals that the water in Pushkar Lake was slightly alkaline. The total alkalinity of water depends on the kind and quality of its constituents, including bicarbonate, carbonate, and hydroxide. The range of TDS values ranged from 332ppm to 462.37ppm. Pushkar Lake had a minimum total hardness of 185.75mg/lt during the study period. The Pushkar Lake's WQI value, which ranged from 94.67 to 124.01, indicated that the water was unfit for drinking. Pushkar Lake's primary source of hardness is the addition of calcium and magnesium through surface run-off during the rainy season. Because of its spiritual significance, Pushkar Lake is revered and visited by pilgrims. Due to the lake's small size and delicate ecology, an increase in tourist activities has had a detrimental effect on its water quality. To address the problem, regular monitoring of water quality is also necessary.

Keywords: Pushkar Lake, Limnology, Physico-Chemical Analysis, Water Quality Index.

Introduction

Water is a crucial element for human and industrial development, as well as the most vulnerable component of the environment[1]. Each destination is a distinct entity in which physical, historical, cultural, social, administrative, or functional aspects combine to create a spatial and functional tourist reality. As a tourist destination, a lake is usually a functionally compact regional whole with identifiable geographical limits. Lakes and reservoirs in dry and semi-arid environments provide a significant source of water for local residents. The interaction of man with water bodies has been a source of concern in recent decades, owing mostly to fast population increase, which has resulted in water body degradation from home, industrial, and agricultural run-off carrying fertilizers and pesticides[2]. Lakes and reservoirs throughout the country have varied degrees of environmental degradation[3]. Significant sources of water pollution are public bathing, the disposal of dead corpses, rural and urban trash, and solid waste disposal[4]. Hydrological factors such as precipitation, water loss due to high heat indices, and man-made perturbations can change the chemical and physical properties of water, and these changes in the physico-chemical environment have a direct impact on the biotic component of the water body[5].

The water quality index (WQI) is one of the most effective instruments for communicating water quality information to concerned citizens and policymakers. WQI measures the overall water quality of a specific location and time. It has evolved into a key measure for assessing and managing water quality for human use[6-8]. Water is considered to be a passive carrier for a variety of organisms, including bacteria, viruses, and protozoa, which can cause a variety of ailments in people. The presence of indicator organisms in water is thought to be a critical component in determining pathogen-caused health problems is currently regarded as ideal fecal indicator bacteria for the global monitoring of fecal contamination in drinking water quality standards and guidelines. The amount of indicator organisms in drinking water should be undetectable in a 100ml sample, according to WHO[9]. Because the bulk of such environmental issues are caused by humans, increased human activity in the catchment region of many aquatic systems has affected the natural processes of these systems, threatening the existence and expansion of biotic communities[10]. One such pilgrim lake is Pushkar Lake, which is important to all tourist activities in the town of Pushkar. The demands of society for economic gain have contributed to the decline of lake water quality and scenic value[11]. Pushkar's survival is largely dependent on the lake.

The major obstacles are in putting sustainable development into action in Pushkar. Millions of people bathe in the lake and engage in other religious activities practically all year, causing an increase in biochemical oxygen demand (BOD), alkalinity, hardness of water, chlorine, magnesium, fluoride, and nitrate levels. Thus, with the extraordinary aesthetic value of Pushkar Lake in mind, as well as the impacts of this water on pilgrims' health and even the health of the local populace who use it frequently for various household purposes, the research of physicochemical characteristics of Pushkar Lake water has been undertaken. Because of the rising importance and dangers to the long-term sustainability of this lake as a result of anthropogenic activities, the current study is particularly relevant. The current analysis attempted to examine the physicochemical features of Pushkar Lake and suggest appropriate restoration techniques.

Materials and Methods

In India, Rajasthan has become a popular tourist destination for visitors from all over the world due to its rich historical, cultural, and environmental heritage, as well as its numerous fairs and festivals. Pushkar is located 12 kilometers northwest of Ajmer. It is situated at an elevation of 530m above sea level at a latitude of 26°27' North and a longitude of 74°37' East. Pushkar is located on the eastern rim of the Thar Desert. It is situated at an elevation of 530m above sea level at a latitude of 26°27' North and a longitude of 74°37' East. Pushkar is located on the eastern rim of the Thar Desert. The depth is approximately 8.3m, with a water volume of 79,287cu.mt[12]. The town is situated in a valley formed by two parallel hills of the Aravalli Mountains that run southwest to northeast. The hills range in height from 650 to 856 meters. Here, sandy soil with a limited water retention capacity predominates. The town is located in a valley formed by two parallel hills of the Aravalli Mountains that run southwest to northeast. The average elevation of these hills ranges from 650 to 856 meters. The subject area is dominated by physicochemical and biochemical weathering. Pushkar's climatic traits include a dry environment, an unpredictable rainfall pattern, and significant temperature changes throughout the year. Even during the rainy season, humidity is minimal. The town has grown all around the lake, These anthropogenic activities and environmental stresses have exceeded Pushkar Lake's carrying capacity and, as a result, damaged the water quality, rendering it unfit for any usage. Keeping in mind the religious, economic, and social value of this Lake and the effect of this water on the health of the local community, the study of the physicochemical properties has been deduced for conservation and management. Figure-1 shows a satellite map of Pushkar Lake.

100 Water samples were taken from four locations from April 2022 to September 2022. The parameters and methods are shown in Table-1.

Water samples were fixed at the sites for the estimation of D.O. and B.O.D. All water samples were examined within 24 hours of being collected. Using conventional techniques, samples were collected in PET bottles. All of the analysis methods followed the standard protocols outlined as per the standard methods described[13-15]. The Water Quality Index (WQI) was used for the estimation of water quality for drinking[16]. The values of unit weight of studied parameters were taken from Chatterjee & Raziuddin[17]. Correlation and other statistical analysis was done by using Microsoft Excel[18].

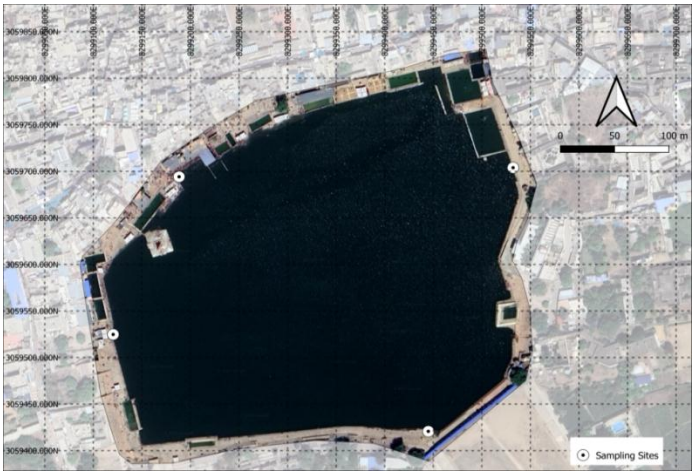

Figure-1: Satellite image of Pushkar Lake.

Table-1: Parameters of water quality assessment and methods used.

Parameters	Methods
Water Temperature	By Digital thermometer (Testo-EN50081)
pH	By Digital pH meter
Electrical Conductivity	By Digital conductivity meter
Total Dissolved Solids (TDS)	By Digital TDS meter
Chloride	Argentometric Method
Alkalinity	By Titrimetric method
Nitrate, Silica, Dissolved Iron	By AQUASOL Test kit (Code : AE-308; 302; 303)
Dissolved Oxygen	By Winkler's Idiometric method
Hardness (Total, Calcium, Magnesium)	By EDTA Titrimetric method
Residual Chlorine	By Iodometric Method
Free CO_2	By Titrimetric method
Sodium & Potassium	By Flame Photometric method
Biochemical Oxygen Demand	By Winkler's Idiometric method (5 day interval)

Results and Discussion

Table-2 provides the average values for general Physico-chemical water quality parameters tested in the four sites on Pushkar Lake and Table-4 shows the trend of water quality in Pushkar lake from the studies since 2008. Due to climatic circumstances and the impact of anthropogenic activities, significant changes in numerous indicators were identified. During the investigation, the minimum temperature was 21^{o}C and the maximum temperature was 25^{o}C. Most biological activities and metabolic reactions are regulated by pH. pH fluctuations are mostly caused by component input into water bodies. The pH of Pushkar Lake's water was ranging from minimum pH of 7.16 to a maximum pH of 7.63. Electrical conductivity levels are primarily determined by ionic concentration or the concentration of dissolved inorganic compounds. The lowest electrical conductivity measured in this investigation was 0.29ms/cm, while the highest was 0.42ms/cm. Total dissolved solids are just the sum of cation and anion concentrations and are measured in milligrams per litre and parts per million. The presence of dissolved particles raises the density of water, influences the osmoregulation of freshwater species, reduces the solubility of gases (such as O_2), diminishes the utility of water for drinking, and contributes to eutrophication of the aquatic ecosystem. The lowest TDS value was 332ppm, while the highest was 462.37ppm. Chloride is abundantly dispersed in nature in the form of sodium, potassium, and calcium salts. The presence of chloride in water indicates contamination, particularly of animal origin. The minimum chloride content in the current investigation was 32.48mg/lt, while the maximum chloride concentration was 39.58mg/lt. The minimum alkalinity concentration in the current investigation was 78.37mg/lt, while the highest alkalinity concentration was 100.37mg/lt. The minimum dissolved oxygen concentration was 5.96mg/lt and the maximum was 9.68mg/lt. In the current investigation, the minimum nitrate was 1.31ppm and the maximum was 4.31ppm, the least silica was 10ppm and the maximum silica was 18.75ppm, the smallest dissolved iron was 0.09ppm and the maximum dissolved iron was 0.21ppm. The biochemical oxygen demand ranged from 20.37mg/lt to 26.23mg/lt. It might be because of an excess of organic matter input from human activities such as offering flowers, garlands, and other sacred objects, feeding fish, birds, and other animals, mass bathing, and so on. During the study period, the minimum total hardness of Pushkar lake was 185.75mg/lt. The addition of calcium and magnesium through surface run-off from agricultural and other catchment areas during the rainy season is the primary source of hardness in Pushkar Lake. As a result, the greatest overall hardness value was found to be 263.75mg/lt. The minimum calcium hardness was 26.4mg/lt, while the maximum was 46.5mg/lt, and the smallest magnesium hardness was 38.71mg/lt, while the maximum was 52.78mg/lt. The minimum carbonate hardness was 69mg/lt, while the maximum was 89.87mg/lt. The minimum non-carbonate hardness was 116.75mg/lt, while the maximum was 173.87mg/lt. The lowest Residual Chlorine concentration was 1.96mg/lt and the highest was 3.24mg/lt. The lowest Free CO_2 concentration was 13.64mg/Lt and the highest was 19.47mg/lt. The lowest sodium concentration was 33.43mg/lt and the highest was 43.91mg/lt. The minimum potassium concentration was 32.15mg/lt, while the maximum was 41.9mg/lt. The water quality index for Pushkar Lake, however, was found to be 107.21, indicating that it is extremely poor and unfit for drinking. This suggests that without proper treatment, the water in Pushkar Lake is unsafe for human consumption. This may be related to the anthropogenic activities that pilgrims carry out nearby that drain contaminants into the Lake (Table-4). Dissolved oxygen shows a strong positive correlation with nitrate and residual chlorine. Strong negative correlation with alkalinity, DO, carbonate hardness, and potassium. Electrical conductivity shows a good correlation with total hardness, magnesium hardness, calcium hardness, non-carbonate hardness. Residual calcium hardness shows a strong positive correlation with non-carbonate hardness, magnesium hardness, and chloride. Moderate negative correlation with alkalinity, residual chlorine, silica, and potassium. Weak positive correlations with nitrate, sodium, and alkalinity (Table-5).

Table-2: Observations of parameter ranges.

Parameter	Unit	Mini.	Maxi.	Avg
Water Temperature	0° C	21	25	24
pH		7.16	7.63	7.31
Conductivity	ms/cm	0.29	0.42	0.34
Total Dissolved Solids	Ppm	332	462.37	377.03
Chloride	mg/L	32.48	39.58	35.89
Alkalinity	mg/L	78.37	100.37	86.02
Nitrate	Ppm	1.31	4.31	2.2
Silica	Ppm	10	18.75	12.65
Dissolved Iron	Ppm	0.09	0.21	0.14
Dissolved Oxygen	mg/L	5.96	9.68	8.03
Total Hardness	mg/L	185.75	263.75	211.25
Calcium Hardness	mg/L	26.4	46.5	33.63
Magnesium Hardness	mg/L	38.71	52.78	43.16
Carbonate Hardness	mg/L	69	89.87	75.4
Non-Carbonate Hardness	mg/L	116.75	173.87	135.84
Residual Chlorine	mg/L	1.96	3.24	2.41
Free CO_2	mg/L	13.64	19.47	15.75
Sodium (Na)	mg/L	33.43	43.91	37.73
Potassium (K)	mg/L	32.15	41.9	37.3
BOD	mg/L	20.37	26.23	23.67

Table-3: Assessment of Water Quality Index.

Parameter	Unit	Avg	Standard value	*Wi*	*Wi*	*Qi*	*WiQi*
pH	-	7.31	7.5	0.218176	0.226909	97.46667	22.11607
Conductivity	ms/cm	0.34	0.3	0.00618	0.006427	113.3333	0.728435
Total Dissolved Solids	ppm	377.03	500	0.003708	0.003856	75.406	0.290797
Chloride	mg/L	35.89	250	0.007416	0.007713	14.356	0.110726
Alkalinity	mg/L	86.02	200	0.001101	0.001145	43.01	0.049249
Nitrate	ppm	2.2	45	0.0412	0.042849	4.888889	0.209485
Dissolved Iron	ppm	0.14	0.3	0.220142	0.228954	46.66667	10.68451
Dissolved Oxygen	mg/L	8.03	5	0.37089	0.385736	160.6	61.94917
Total Hardness	mg/L	211.25	200	0.00618	0.006427	105.625	0.678891
Calcium Hardness	mg/L	33.63	75	0.02472	0.025709	44.84	1.152813
Magnesium Hardness	mg/L	43.16	30	0.0618	0.064274	143.8667	9.246843
				Σwi=0.961513	Σwi=1	ΣQi=850.0592	ΣWiQi=107.217

Here, V*i*= Monitored Value, S*i*= Recommended standard value, w*i*= *Unit weightage*,$Wi = \frac{wi}{\Sigma wi}$, $= 100[{}^{Vi}/_{Si}]$,$WQI = \Sigma WiQi$

Table-4: Comparison of present study with previous studies for trend analysis:

Parameters(Units)	2008[19]	2009[20]	2011[12]	2012[21]	Present study of Pushkar Lake
Temperature(°C)	21.98	27.39	15.66	23.11	24
Alkalinity (mg/l)	138.71	537.49	127.5	20.33	86.02
pH	7.67	7.85	7.65	6.78	7.31
CO_2 (mg/l)	NA	27.37	NA	70.89	15.75
Chloride (mg/l)	34.67	NA	46.25	50.18	35.89
Hardness (mg/l)	130.71	223.32	NA	53.33	211.25
DO (mg/l)	5.88	4.72	4.81	5.58	8.03
Conductivity (ms/cm)	0.23	1.285	0.42	0.75	0.34
BOD (mg/l)	8.1	NA	4.93	37.31	23.67
TDS (ppm)	266.28	847.36	NA	NA	377.03
Ca Hardness (mg/l)	NA	165.83	NA	NA	33.63
Mg Hardness (mg/l)	NA	72.79	NA	NA	43.16
Sodium	NA	38.33	43.75	NA	37.73
Potassium	NA	23.78	9	NA	37.3
Nitrate (ppm)	19.26	1.028	NA	NA	2.2

Table-5: Correlation between observed parameters (Here P=Parameters, 1=Temperature, 2=pH, 3=Conductivity, 4=Total Dissolved solids, 5= Dissolved Oxygen, 6=Biological Oxygen Demand, 7=Total Hardness, 8=Calcium Hardness, 9=Magnesium Hardness, 10=Carbonate Hardness, 11=Non-Carbonate Hardness, 12=Free Carbon di-oxide, 13=Residual Chlorine, 14= Chloride, 15=Alkalinity, 16=Nitrate, 17=Silica, 18=Iron, 19=Sodium, 20=Potassium).

P	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2	-0.27																			
3	-0.13	-0.34																		
4	-0.20	-0.44	0.96																	
5	-0.04	-0.26	-0.05	-0.04																
6	0.44	-0.32	-0.23	-0.16	0.26															
7	0.11	-0.65	0.90	0.91	0.02	0.13														
8	0.22	-0.76	0.81	0.81	0.26	0.21	0.96													
9	0.08	-0.63	0.91	0.92	-0.03	0.11	1.00	0.94												
10	0.13	-0.17	0.35	0.35	-0.83	-0.38	0.34	0.16	0.37											
11	0.10	-0.66	0.89	0.91	0.07	0.16	0.99	0.97	0.98	0.28										
12	-0.46	-0.43	0.72	0.81	0.00	0.09	0.74	0.63	0.75	0.12	0.74									
13	-0.39	0.38	0.03	0.00	0.70	-0.01	-0.17	-0.08	-0.19	-0.84	-0.12	0.07								
14	0.12	-0.44	0.84	0.85	-0.13	-0.33	0.79	0.73	0.79	0.53	0.77	0.41	-0.20							
15	0.08	-0.10	-0.60	-0.62	0.61	0.11	-0.48	-0.26	-0.52	-0.49	-0.46	-0.56	0.16	-0.50						
16	-0.21	0.25	-0.42	-0.49	0.76	-0.09	-0.51	-0.32	-0.54	-0.76	-0.47	-0.43	0.66	-0.49	0.82					
17	-0.51	0.20	-0.10	-0.11	0.58	0.25	-0.18	-0.11	-0.19	-0.82	-0.13	0.31	0.79	-0.53	0.17	0.53				
18	-0.18	0.11	0.18	0.36	-0.02	0.04	0.16	0.07	0.18	0.04	0.16	0.18	0.17	0.37	-0.32	-0.20	-0.16			
19	0.28	0.41	-0.43	-0.62	0.30	-0.21	-0.54	-0.39	-0.56	-0.33	-0.53	-0.82	0.25	-0.36	0.66	0.71	0.00	-0.41		
20	-0.19	-0.07	0.08	-0.01	-0.02	-0.83	-0.13	-0.08	-0.13	0.29	-0.15	-0.21	-0.15	0.23	0.28	0.25	-0.27	-0.41	0.37	

Conclusion

According to the study's findings, the Water Quality Index (WQI) indicates that the water is unfit for drinking (WQI=107.21) because it is considered sacred and is consumed by pilgrims because of the religious significance of Pushkar Lake. Dissolved Oxygen (DO) is the single most important factor contributing to water quality degradation. A large amount of organic material is deposited in Pushkar Lake on a daily basis, such as flower remnants, ashes residues, feeding fish with artificial foods, and so on, which accelerates the decomposition process, resulting in increased Biological Oxygen Demand (BOD) and lower Dissolved Oxygen. Total Dissolved Solids, Hardness, Sodium, Potassium and Free Carbon di-oxide also contributes in reducing water quality of Pushkar Lake. An increase in tourist activities within this lake's restricted size and vulnerable ecology has had a negative influence on its water quality. To address the issue of deteriorating water quality, lake management should include and encourage the establishment of a particular location or ghats for the submersion of organic material, and keep the amount of waste under control. Also, water from these ghats should be treated before being discharged into the lake. Water quality should also be monitored on a regular basis. People who engage with the lake require environmental education to be aware of the long-term repercussions of water contamination.

References

1. Das, J. and Acharya, B.C. (2003). Hydrology and assessment of lotic water quality in Cuttack city, India. *Water, Air, Soil Pollution*, 150, 163-175.

2. Prasad, S. N., Ramachandra, T. V., Ahalya, N., Sengupta, T., Kumar, A., Tiwari, A. K., Vijayan, V. S. & Vijayan, L.

(2002). Conservation of wetlands of India-a review. *Tropical Ecology*, 43(1), 173-186.

3. Reddy, M. S., & Char, N. V. V. (2006). Management of lakes in India. *Lakes & Reservoirs: Research & Management*, 11(4), 227-237.

4. Tiwana, A. J. (1992). Water resource management quality and quality aspects. Proc. Int. Con. Rural works and sanitation in developing countries, IWWA, Nagpur, India, 6-17.

5. Sharma, R., & Sharma, K. C. (1993). A note on trophic state of Anasagar lake, Ajmer. *Geobios new report*, 10, 158-159.

6. Mishra, P. C., & Patel, R. K. (2001). Study of the pollution load in the drinking water of Rairangpur, a small tribal dominated town of North Orissa. *Indian J Environ Ecoplan*, 5(2), 293-298.

7. Naik, S., & Purohit, K. M. (2001). Studies on water quality of river Brahmani in Sundargarh district, Orissa. *Indian J Environ Ecoplan*, 5(2), 397-402.

8. Tiwari, T. N., & Mishra, M. A. (1985). A preliminary assignment of water quality index of major Indian rivers. *Indian J Environ Prot*, 5(4), 276-279.

9. Khan, K., Lu, Y., Saeed, M. A., Bilal, H., Sher, H., Khan, H., Ali, J., Wang, P., Uwizeyimana, H., Baninla, Y., Li, Q., Liu, Z., Nawab, J., Zhou, Y., Su, C., & Liang, R. (2018). Prevalent fecal contamination in drinking water resources and potential health risks in Swat, Pakistan. *Journal of Environmental Sciences*, 72, 1-12. http://dx.doi.org/10.1016/j.jes.2017.12.008.

10. Bhatt, N. A., Tank, P. R., Kavindra, J. and Sharma, B. K. (2018). Age, growth and harvestable size of *Catla catla* (Ham.) from Khodiyar Dam, Dhari, Gujarat. *Journal of entomology and zoology studies*, 6(2), 623-628.

11. Ranade, P. S. (2008). Managing Lake Tourism: Challenges Ahead. Conference on Tourism in India, 15- 17 May, IIMK. 543-554.

12. Sharma, S., Yadav, R. K., Saini, Y. A. S. H. O. D. A., & Sharma, S. H. W. E. T. A. (2011). Water quality status of Pushkar lake as a primary data for sustainable development. *South Asian Journal of Tourism and Heritage*, 4(2), 184-192.

13. Clesceri, L. S. (1998). Standard methods for examination of water and wastewater. *American public health association*, 9.

14. Trivedy, R. K., & Goel, P. K. (1984). Chemical and biological methods for water pollution studies. *Environmental publications*.

15. Maiti, S. K. (2001). Water and wastewater analysis. Handbook of methods in environmental studies. Vol 1: ABD Publishers.

16. Horton, R. K. (1965). An index number system for rating water quality. *J Water Pollut Control Fed*, 37(3), 300-306.

17. Chaterjee, C., & Raziuddin, M. (2002). Determination of water quality index (WQI) of a degraded river in Asanol Industrial area, Raniganj, Burdwan, West Bengal. *Nature Environment and Pollution Technology*, 2, 181-189.

18. Microsoft Corporation (2018). Microsoft Excel. Retrieved from https://office.microsoft.com/excel.

19. Mathur, P., Agarwal, S., and Nag, M. (2008). Assessment of Physico-chemical Characteristics and Suggested Restoration Measures for Pushkar Lake, Ajmer, Rajasthan (India). Proceedings of Taal 2007: The 12th World Lake Conference: 1518-1529.

20. Sharma, K. C., Chouhan, C. S., Charan, P. D., and Nag, M. (2009). Water Quality And Restoration Practices of Lake Budha Pushkar Pushkar- A Threatened Water Body of Ajmer, Rajasthan. *The Ecoscan*, 3 (1&2), 53-58.

21. Verma, S., and Summarwar, S. (2012). Abalysis of Water of Pushkar Lake before, during and after the Pushkar Fair. *Int. J. LifeSc. Bt & Pharm*. 1(4), 35-41.