Research Article

Shailja Sharma, Prasenjit Mitra, Pankaj Bhardwaj and Praveen Sharma*

Blood lead level in school going children of Jodhpur, Rajasthan, India

https://doi.org/10.1515/tjb-2020-0418
Received August 26, 2020; accepted December 26, 2020; published online February 4, 2021

Abstract

Objectives: Lead exposure in children contributes to 600,000 new cases of intellectual disabilities every year with maximum occurrence in developing countries. Currently limited information is available on the blood lead level (BLL) in children of India. The aim was to estimate BLL in the school going children of local population of Jodhpur.

Methods: Four hundred twenty-six primary school children of government and private schools participated in this cross sectional study. Information regarding possible lead exposure was collected. BLL was estimated on Lead Care II analyser (Magellan Diagnostics, USA).

Results: The mean and median BLL were 4.25 ± 1.75 μg/dL (<3.3–22.6 μg/dL) and 3.5 μg/dL (Inter Quartile Range 0.9). BLL was higher in children of illiterate mothers, those residing near traffic dense areas, urban region and studying in government schools of urban region.

Conclusions: BLL in children residing in Jodhpur is much higher in comparison to western counterparts. Screening and awareness programs regarding potential sources of lead exposure can help in improving BLL.

Keywords: BLL; children; lead; risk factors; school

Introduction

Lead (Pb) is a highly toxic heavy metal occurring naturally in the Earth’s crust. Due to its environmental persistence, transportability and non-biodegradable nature, it has the potential to cause many deleterious systematic effects [1]. Globally approximately 815 million children are estimated to have blood lead level (BLL) > 5 μg/dL and out of those, nearly 50% children are residing in Southeast Asia. This analysis was undertaken using the Global Burden of Disease dataset for 2019 and includes all countries [2]. In 2017 alone, Pb exposure in India resulted in over 230,000 premature deaths, amounting to a cumulative loss of over 5.2 million years of life. Long-term disability from Pb exposure resulted in the loss of an additional 7 million years of healthy life. Troublingly, these numbers represent an increase of 53 and 30% in death and disability respectively since the 1996–2000 phase out of leaded gasoline [3].

Potential Pb exposure occurs from various human activities such as mining, manufacturing, burning fossil fuels, drinking water where Pb pipes are used, old leaded paint, pigments, glazed pottery, some healthcare products and folk remedies [4–7]. A larger percentage of Pb is absorbed and retained by children because of their behaviour and developing organ systems resulting in disproportionately higher side effects at lower levels of exposure than adults [6]. Lead affects all organ systems and eventually majorly deposits in bones [6]. BLL >5 μg/dL were associated with lower intelligence quotient and even lower BLL has been reported to be associated with poor academic performance and attention-related problems [6].

The George Foundation under the “Project Pb Free” in late nineties assessed BLL of 22,000 children from seven major cities of India and concluded that 51% of children up to 12 years, had blood Pb level (BLL) more than 10 μg/dL [8]. A recent meta analysis reported pooled arithmetic mean for BLL in Indian children to be 6.86 μg/dL (95% CI: 4.38–9.35). This analysis did not have any representation from Rajasthan state [9].

According to World Health Organisation, BLL of any concentration is not considered safe and level as low as 5 μg/dL, may be related to diminished intelligence in children, behavioural and learning problems [10]. It is reported that increased Pb exposure is associated with increased severity of symptoms and effects [10]. Evidence from a number of scientific studies corroborated that even low BLL can cause
lifelong health-related side effects [6, 11, 12]. Children exposed to lead after being followed for 30 years, reported difficult personality traits in their adulthood and greater psychiatric and behavioural consequences in adult life [13]. Eventually BLL of concern from 10 μg/dL was reduced to 5 μg/dL by Centre for Disease Control and prevention (CDC) [5]. Lead pollution is widely prevalent in India [10] and contributes towards behavioural deficits with lower functional skills during childhood and later in life [13, 14]. Lead pollution is widely prevalent in India [10] and contributes towards behavioural deficits with lower functional skills during childhood and later in life [13, 14]. Lead pollution is widely prevalent in India [10] and contributes towards behavioural deficits with lower functional skills during childhood and later in life [13, 14]. Lead pollution is widely prevalent in India [10] and contributes towards behavioural deficits with lower functional skills during childhood and later in life [13, 14].

Measurement of BLL

Blood lead level was measured with Lead Care II (Magellan Diagnostics, Inc. 101 Billerica Ave, Building 4 N. Billerica, Massachusetts 01862-1271 USA) blood Pb analyzer at our institute within the same day or maximum within 24 h of sample collection. This device estimates Pb between 3.3 and 65 μg/dL and is based on the principle of anodic stripping voltammetry. The reliability and validity of Lead Care II has been well established and it is used worldwide for blood lead screening [18, 19]. The device was calibrated for each 48-batch run and quality controls were run with every 20 samples, every new batch, and kit lot. The quality control values for level 1 were 6.3 ± 3 μg/dL and level 2 were 26.5 ± 4.6 μg/dL. Any value below the detection limit of 3.3 μg/dL was allocated a value of 1.65 μg/dL (midpoint between 0 and 3.3 μg/dL) for statistical analysis. Any sample with BLL ≥5 μg/dL was repeated to verify and the average value was taken as final value.

Materials and methods

The study was approved by the institutional ethics committee and ethical clearance was obtained (letter no. AIIMS/IEC/2014/330 dated 15/09/2014). This was a cross sectional study conducted between Oct 2015 and Dec 2017. A list of all the private and government schools was procured from the office of District Education Officer (DEO). From this list, seven private and seven government schools were selected randomly. From each school 30 students were recruited randomly. The figure of 30 was finalized considering the less enrolment of students in most of the government schools located in the peripheral areas of Jodhpur.

Total five hundred primary school children (5–12 years) were selected randomly. The method ensured better representation of different socio-demographic profile of the Jodhpur city. Written informed consent was sought from parents/guardians. Four hundred twenty-six parents/guardians consented for the study. Consenting parents/guardians were required to complete a questionnaire. The questionnaire entailed the personal details, educational status of parents, complaints suggestive of Pb toxicity like fatigue, loss of appetite, stomach ache, poor academic performance, behavioural problems, dietary habits, history of pica. Special note on the place of dwelling, proximity of home to highway/traffic density etc. were noted.

Sample collection

Blood sample was collected in the school in the designated clean area to minimize contamination, after collecting the informed consent sheet and questionnaire. The skin at the site of the blood draw was thoroughly washed to remove any external traces of Pb to minimize potential external contamination of blood sample. About 3 ml blood was collected by trained phlebotomist in EDTA vacutainer (BD, USA) after cleaning the venipuncture site with alcohol swab. The samples were kept in coolers with ice packs while sampling and transported to departmental laboratory.

Statistical analysis

Data was analysed using SPSS version 21(IBM) and Graphpad prism version 8.0 software. Shapiro Wilk’s test was used to check for normal distribution of data. The values were expressed as mean ± SD and median interquartile range (IQR). Mann–Whitney and Kruskal–Wallis test were applied to assess the statistical significance of various variables in predicting BLL. Chi square test was done to see association of increased BLL with various contributing factors. Logistic Regression analysis was done to study the effect of various independent variables on BLLs. p<0.05 was considered significant.

Results

The study was conducted on 426 school going children. Out of these, 277 (65%) were boys 149 (35%) were girls. The mean age of children was 9 years (5–12 years). Their mean BLL was 4.25 ± 1.75 μg/dL (<3.3–22.6 μg/dL) with median 3.5 μg/dL (IQR 0.9). The mean BLL in boys was 4.21 ± 1.42 μg/dL (<3.3–22.6 μg/dL) with median 3.5 μg/dL (IQR 0.82) and in girls 3.7 ± 1.22 μg/dL (<3.3–10.5 μg/dL) with median 3.5 μg/dL (IQR 0.97). Out of the total, 61.7% (n=253) children had BLL <3.5 μg/dL, 19.5%(n=81) had 3.5–5 μg/dL, 17.37% (n=74) had 5–<10 μg/dL, 0.94% (n=4) had 10–<15 μg/dL and 0.47% (n=1) had BLL >15 μg/dL. Therefore 18.87% (n=80) of children crossed the CDC intervention level of 5 μg/dL (Figure 1).

Median BLL is mentioned across the variables of interest as shown in Table 1. There was significant difference between the median BLL in children in context of...
BLL, blood lead level, *p value < 0.05 considered significant.

The children in urban region had significantly higher BLL in comparison to periurban inhabitants (3.95 µg/dL [IQR 1.3] vs. 3.5 µg/dL [0.2], p=0.01*). It was observed that higher percentage of urban region children had BLL >5 µg/dL (22.2%, n=65) in comparison to periurban inhabitants (9.02%, n=12). Out of 293 children of urban locality, government school children had significantly higher BLL in comparison to those attending private schools (4.9 µg/dL [IQR 2.45] vs. 3.5 µg/dL [IQR 0.22], p=0.0001*).

Factors contributing towards increased BLL in urban region children were explored. It was seen that significantly higher percentage of children going to urban government schools were residing in old housing and using cosmetics like surma/kohl, folk medicines, potable water without any purification system (Table 2). Logistic regression was used to study the effect of various independent variables on BLL. Mother’s education status (p=0.007) and the highway/traffic near residence (p<0.001) were found to be significantly associated with BLL (Table 3).

**Discussion**

Lead has a wide range of industrial use and human exposure results in well recognized adverse health effects [4]. In late nineties more than 50% children in India had BLL >10 µg/dL [8]. Previously BLL up to 10 µg/dL was acceptable which was further brought down to 5 µg/dL [5]. Evidence suggests that BLL ≥5 µg/dL is associated with irreversible neurologic damage and behavioural problems [13, 14, 20]. Currently CDC statement considers no BLL to be safe for children [5]. The median BLL 3.5 µg/dL (IQR 0.9) observed in the present study is lower than mean BLL of children from other parts of India [9]. Invariably 18.8% of children crossed the CDC intervention level of 5 µg/dL in the present study. Children residing in areas rich in traffic density or closer to highway had significantly higher BLL (Tables 1 and 3). Similar findings have been supported by others also [21]. It has been reported that soil, water, and air around highways and traffic dense area have significantly higher Pb content [22, 23] with major contribution from vehicular emission which is responsible for more than 90 percent of all atmospheric emission and roadside soil Pb content [24]. Roadside soil Pb and traffic density of the road

**Table 1:** Factors associated with BLL in school children.

| Characteristics                  | Number | %    | BLL, µg/dL Median (IQR) | p-Value |
|----------------------------------|--------|------|-------------------------|---------|
| **Gender**                       |        |      |                         |         |
| Boys                             | 277    | 65   | 3.5 (0.82)              | 0.65    |
| Girls                            | 149    | 35   | 3.5 (0.97)              |         |
| **Highway/Traffic near residence** |      |      |                         |         |
| <1 km                            | 136    | 31.9 | 4.4 (0.15)              | 0.0001* |
| >1 km                            | 290    | 68.1 | 3.5 (2.35)              |         |
| **Mother’s education status**    |        |      |                         |         |
| Illiterate                       | 49     | 11.5 | 3.7 (1.85)              | 0.0001* |
| Primary                          | 59     | 13.8 | 3.8 (1.4)               |         |
| Secondary                        | 84     | 19.7 | 3.5 (2.2)               |         |
| Graduate and above               | 234    | 54.9 | 3.5 (0.4)               |         |
| **Locality**                     |        |      |                         |         |
| Urban                            | 293    | 66.7 | 3.95 (1.3)              | 0.01*   |
| Peri urban                       | 133    | 33.3 | 3.5 (0.2)               |         |
| **School (urban region)**        |        |      |                         |         |
| Government                       | 79     | 26.1 | 4.9 (2.45)              | 0.0001* |
| Private                          | 214    | 73.9 | 3.5 (0.22)              |         |

**Table 2:** Determinants for BLL >5 µg/dL in urban school children (n=293).

| Determinants                  | Govt. (n=79) | Private (n=214) | p-Value |
|-----------------------------|--------------|-----------------|---------|
| No water purifier            | 51 (64.5%)   | 14 (6.5%)       | <0.00001|
| Old housing                  | 39 (49.3%)   | 19 (8.8%)       | <0.00001|
| Cosmetics (surma/kohl)       | 26 (32.9%)   | 17 (7.9%)       | <0.00001|
| Herbal medicine use          | 15 (18.9%)   | 21 (9.8%)       | 0.0337  |

BLL, blood lead level, p<0.05 considered significant.
were also found to be linked [25, 26]. Seasonal variation of Pb in soil has been found to be associated with BLL variation. Zahran et al. [27] have hypothesized that Pb in soil enters blood through inhalation of contaminated air dust. In other words, having residence near highway or traffic dense area can be a risk factor for increased BLL [28]. The urban subset of children had significantly higher BLL in comparison to periurban school children as reported earlier [29]. 24.2% children going to government schools and 12.04% to private schools in urban locality had BLL >5 \mu g/dL. There are reports of elevated BLL in developing countries in urban areas where exposure to industrial paint sources and fossil-fuel burning are relatively high [30–32]. Socioeconomic conditions reflect BLL [30]. Jain et al. [32] reported that standard of living correlated with a 32.3% increase in BLLs (p=0.02). We did not directly estimate socioeconomic status (SES) index but it was observed that parents of the urban government school students majorly belonged to lower socioeconomic status as depicted by their occupation which can be an indirect indicator of SES. Poor nutrition of children belonging to low SES may also increase their susceptibility to the Pb-related health effects [21]. Few studies have focussed on rural children, and have found lower Pb exposure or lower BLL in rural vs. urban population [29, 33].

BLL was significantly higher in children of illiterate mothers when compared to graduate mothers (Table 1). In Indian education system, being graduate entails 15 years of formal education. Mother’s illiteracy was predictor of BLL (Table 3). Education brings awareness to the parent about different sources of Pb exposure and subsequently its influence on children’s health. Hence dearth in education would generally result in lack of any preventive measures at individual level.

Older housing is potentially linked with exposure to not only leaded paints but also Pb piping, a known risk factor for high BLL [34]. Around 76% children in urban region were residing in old houses with metallic plumbing in comparison to children of periurban region (57.1%). In addition to this 52% of urban children with increased BLL were residing in houses which were recently painted. Indian paints are high in Pb content. Recent Indian study assessed store-bought cans of enamel paint for Pb levels and found that 46% of those tested contained >10,000 ppm Pb [35]. Others have also suggested Pb-based paints to be contributory factor for BLL [36]. Houses of most of the children in periurban region were not painted/freshly painted which could be the reason for lower BLL observed in this subset. Herbal medications, cosmetics like kohl, surma are rich in Pb and hence potential cause of Pb toxicity [4–6, 37]. Usage of herbal/folk medicines along with surma/kohl usage was also observed in children with BLL>5 \mu g/dL (Table 2). Water can be a potential source of Pb exposure [38] and the local water body supplying to the Jodhpur population has been reported to have high Pb content of 250 ppb as reported previously [39] whereas Environmental Protection Agency advocates 15 ppb to be the upper permissible limit for consumption [7]. Children from urban backgrounds with increased BLL were dependent on municipal water supply and were not using any water purification system in 76.1% of the cases. In contrast, all the children with increased BLL from periurban part of the city did not have water purification system at home but were buying water from a local supplier which was true for other students of periurban region as well.

## Conclusion

In the present study, 18.87% of school going children had BLL (>5 \mu g/dL) which is considerably higher in comparison to western counterparts. Lead toxicity is preventable and

| Variables         | p-Value | OR (95%CI) | p-Value | AOR (95%CI) |
|-------------------|---------|------------|---------|-------------|
| Mother’s education|         |            |         |             |
| Graduate and above| <0.001  | 4.02 (2.09–7.73) | 0.007   | 5.84 (1.63–21.00) |
| Secondary         | 0.023   | 2.31 (1.12–4.76) | 0.058   | 2.26 (0.97–5.23) |
| Primary           | 0.214   | 1.69 (0.74–3.86) | 0.135   | 2.06 (0.80–5.30) |
| Illiterate        |         | 1          |         | 1           |
| School            |         |            |         |             |
| Private           | 0.008   | 1.98 (1.20–3.28) | 0.908   | 1.07 (0.34–3.33) |
| Government        |         |            |         |             |
| Traffic           |         |            |         |             |
| Traffic (>1 km)   | <0.001  | 7.59 (4.42–13.04) | <0.001  | 9.42 (5.20–17.07) |
| Traffic (<1 km)   |         |            |         |             |
| Gender            |         |            |         |             |
| Female            | 0.278   | 1.34 (0.79–2.29) | 0.291   | 1.39 (0.75–2.57) |
| Male              |         |            |         |             |

BLL, blood lead level, p<0.05 considered significant; OR, odds ratio; AOR, adjusted odds ratio; CI, confidence interval.
no level of exposure to this widely prevalent metal is known to be without deleterious health effects. Hence regular screening programs for Pb exposure by estimating BLL are recommended for school children along with aggressive awareness programs for the community. The information would be invaluable to formulate strategies for public health implications of Pb exposure and its detrimental effects on children.

**Research funding:** The study was supported by institutional grant no AIIMS/Res (01)2014/07.

**Author contributions:** PS and SS conceptualized and executed the study. PB, PM and SS made the study design and analysed the results. PS, SS, PB and PM drafted the paper.

**Competing interests:** Authors state no conflict of interest.

**Ethical approval:** Ethical clearance was obtained from institutional ethics committee (letter no. AIIMS/IEC/2014/330 dated 15/09/2014).

### References

1. Mitra P, Sharma S, Purohit P, Sharma P. Clinical and molecular aspects of lead: an update. Crit Rev Clin Lab Sci 2017;54:506–28.
2. The toxic truth: children’s exposure to lead pollution undermines a generation of future potential. UNICEF and PURE EARTH; 2020.
3. GBD Compare [Internet]. Institute for Health Metrics and Evaluation; 2020. Available from: <http://www.healthdata.org/data-visualization/gbd-compare>[Accessed 22 Aug 2020].
4. Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile: lead. Available from: <https://www.atsdr.cdc.gov/toxprofiles/toxProfiles.asp?id=96&tid=22>[Accessed 24 Aug 2020].
5. Blood lead levels in children [lead] CDC [Internet]. Cdc.gov; 2020. Available from: <https://www.cdc.gov/cnch/lead/prevention/blood-lead-levels.htm>[Accessed 23 Aug 2020].
6. Case studies in environmental medicine (CSEM). Lead toxicity. ATSDR; 2017. Available from: <https://www.atsdr.cdc.gov/csem/lead/docs/CSEM-lead_toxicity_508.pdf>[Accessed 20 Aug 2020].
7. Basic information about lead in drinking water | US EPA [Internet]. US EPA. Available from: <https://www.epa.gov/ground-water-and-drinking-water/basic-information-about-lead-drinking-watergetinto>[Accessed 12 Oct 2020].
8. Lead poisoning prevention in India: the George Foundation [Internet]. Tgfworld.org; 2020. Available from: <http://tgfworld.org/lead.html>[Accessed 23 Aug 2020].
9. Ericson B, Dowling R, Dey S, Caravanoosa J, Mishra N, Fisher S, et al. A meta-analysis of blood lead levels in India and the attributable burden of disease. Environ Int 2018;121:461–70.
10. Lead poisoning and health [Internet]. Who.int; 2020. Available from: <https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health>[Accessed 23 Aug 2020].
11. Spivey A. The weight of lead. Effects add up in adults. Environ Health Perspect 2007;115:A30–6.
12. Bellinger DC. Childhood lead exposure and adult outcomes. J Am Med Assoc 2017;317:1219–20.
13. Reuben A, Schaefer JD, Moffitt TE, Broadbent J, Harrington H, Houts RM, et al. Association of childhood lead exposure with adult personality traits and lifelong mental health. JAMA Psychiatry 2019;76:418–25.
14. Sharma P, Chambial S, Shukla KK. Lead and neurotoxicity. Indian J Clin Biochem 2015;30:1–2.
15. Singh AK, Singh M. Lead decline in the Indian environment resulting from the petrol-lead phase-out programme. Sci Total Environ 2006;368:686–94.
16. Chambial S, Shukla KK, Dwivedi S, Bhardwaj P, Sharma P. Blood lead level (BLL) in the adult population of Jodhpur: a pilot study. Indian J Clin Biochem 2015;30:357–9.
17. Pureearth.org. Available from: <https://www.pureearth.org/wp-content/uploads/2017/08/Jodhpur-Pali-Balotra_India-PCR.pdf>[Accessed 12 Oct 2020].
18. Centers for Disease Control and Prevention Advisory Committee on childhood lead poisoning prevention guidelines for measuring lead in blood using point of Care instruments. Available from: <http://www.cdc.gov/nceh/lead/ACCLPP/20131024_POCguidelines_final.pdf>[Accessed 1 Oct 2020].
19. Zamani N, Gholami N, Hassanian-Moghaddam H, Farnaghi F, Gachkar L. Factors associated with high blood lead levels in a sample of 100 children in Tehran. Clin Med Insights Pediatr 2019;13. https://doi.org/10.1177/1179556518825451.
20. Bellinger DC, Stiles KM, Needleman HL. Low-level lead exposure, intelligence and academic achievement: a long-term follow-up study. Pediatrics 1992;90:855–61.
21. Ahamed M, Verma S, Kumar A, Siddiqui MK. Blood lead levels in children of Lucknow, India. Environ Toxicol 2010;25:48–54.
22. Ramakrishnaiah H, Somashekar RK. Heavy metal contamination in roadside soil and their mobility in relations to pH and organic carbon. Soil Sediment Contam 2002;11:643–54.
23. Gulson B, Taylor A, Stifelman M. Lead exposure in young children over a 5-year period from urban environments using alternative exposure measures with the US EPA IEBUK model – a trial. Environ Res 2018;161:87–96.
24. Mielke HW, Laidlaw MA, Gonzales C. Lead (Pb) legacy from vehicle traffic in eight California urbanized areas: continuing influence of lead dust on children’s health. Sci Total Environ 2010;408:3965–75.
25. Teju E, Megersa N, Chandrvanshi BS, Zewge F. Lead accumulation in the roadside soils from heavy density motor way towns of eastern Ethiopia. Bull Chem Soc Ethiop 2014;28:161–76.
26. Teju E, Megersa N, Chandrvanshi BS, Zewge F. Determination of the levels of lead in the roadside soils of Addis Ababa, Ethiopia SINET Ethiop. J Sci 2013;35:81–94.
27. Zahran S, Laidlaw MAS, McElmurry SP, Filippelli GM, Taylor M. Linking source and effect: resuspended soil lead, air lead, and children’s blood lead levels in Detroit, Michigan. Environ Sci Technol 2013;47:2839–45.
28. Rahbar MH, Samms-Vaughan M, Dickerson AS, Loveland KA, Ardjomand-Hessabi M, Bressler J, et al. Factors associated with blood lead concentrations of children in Jamaica. J Environ Sci Health A 2015;50:529–39.
29. Alvarez J, Del Rio M, Mayorga T, Dominguez S, Flores-Montoya MG, Sobin C, et al. A comparison of child blood lead levels in urban and rural children ages 5–12 years living in the border
30. Rahbar MH, White F, Agboatwalla M, Hozhabri S, Luby S. Factors associated with elevated blood lead concentrations in Karachi, Pakistan. Bull World Health Organ 2002;80:769–75.

31. Heinze I, Gross R, Stehle P, Dillon D. Assessment of lead exposure in schoolchildren from Jakarta. Environ Health Perspect 1998;106:499–1.

32. Jain NB, Hu H. Childhood correlates of blood lead levels in Mumbai and Delhi. Environ Health Perspect 2006;114:466–70.

33. Mitra AK, Ahua E, Saha PK. Prevalence of and risk factors for lead poisoning in young children in Bangladesh. J Health Popul Nutr 2012;30:404–9.

34. Brown MJ, Raymond J, Homa D, Kennedy C, Sinks T. Association between children’s blood lead levels, lead service lines, and water disinfection, Washington, DC, 1998–2006. Environ Res 2011;111:67–4.

35. National report: lead in enamel household paints in India in 2015. Available from: http://toxicslink.org/docs/Lead-in-Paint-Report-2015.pdf [Accessed 14 Mar 2019].

36. Khan MI, Ahmad I, Mahdi AA, Akhtar MJ, Islam N, Ashquin M, et al. Elevated blood lead levels and cytogenetic markers in buccal epithelial cells of painters in India. Environ Sci Pollut Res 2010;17:1347–54.

37. Chambial S, Bhardwaj P, Mahdi AA, Sharma P. Lead poisoning due to herbal medications. Indian J Clin Biochem 2017;32:246–47.

38. Jakhu R, Mehra R. Risk estimation and multivariate statistical analysis of the heavy metal content of drinking water samples. Toxicol Ind Health 2018;34:714–25.

39. Mohan D, Chaudhary A, Gaur S. Patterns of trace metals accumulation in different trophic layer of lake kailana, Jodhpur. In: Proceedings of Taal 2007: the 12th world lake conference: 373–4 pp.