journal of Geoethics and social Geosciences

Journal of Geoethics and Social Geosciences, 01, 02, 2026; doi:10.4401/jgsg-126

Emergence of new CKDu hotspots in rural areas of India: a comprehensive overview of environmental, socio-legal and health implications

Anjali Vijayan[1], *Neena Elezebeth Philip*[2], *Lekha D Bhat*[*,2], *Bhagyalakshmi R.*[3]

[1] Department of Geology, Central University of Tamil Nadu, Thiruvarur 610005, India

[2] Department of Epidemiology and Public Health, Central University of Tamil Nadu, Thiruvarur 610005, India

[2] Department of Law, Central University of Tamil Nadu, Thiruvarur 610005, India

Article history: received July 31, 2026; accepted October 20, 2026; published November 4, 2026

Abstract

Chronic Kidney Disease of Unknown Etiology (CKDu) emerges as a public health concern, particularly in low- and middle-income countries. Recent studies indicate a considerable rise in CKDu cases and the emergence of new hotspots in rural India, where minimal healthcare access and poor working conditions exacerbate vulnerability. Higher prevalence of Chronic Kidney Disease without attributing a cause, mostly prevalent in Southern India. Cases are predominantly reported from Telengana, Andra Pradesh, Tamil Nadu, Goa, Odisha, Punjab and Chattisgarh. In India, the disparity in healthcare infrastructure, particularly for dialysis and transplantation, along with social stigma, hampers effective management and early detection. Addressing CKDu demands an integrated approach from environmental, legal, public health and policy framework for ensuring enhanced water quality assessments. Early diagnostic measures, engaging multidisciplinary research and drawing lessons from global experiences to formulate evidence-based interventions is pivotal.

Keywords: Chronic Kidney Disease of Unknown Etiology, CKDu, Water Quality, Legal-institutional measures, India.

1. Introduction

Chronic Kidney Disease (CKD) has become an alarming public health issue globally, particularly in low- and middle-income countries. CKD prevalence has been reported to range from 11% to 13% (Hill et al., 2016). Chronic Kidney Disease of Unknown etiology (CKDu) is a term applied to CKD, frequently reported in agricultural communities, that occurs in the absence of traditional causes such as diabetes, long-standing or severe hypertension, glomerulonephritis or other identifiable kidney disease. Operational case definitions differ across regions and studies, and there is currently no globally agreed definition (Johnson et al., 2019; John et al., 2021). Recent surveys and studies have identified a substantial increase in CKDu cases and identification of new CKDu hotspots across various regions in India, particularly in rural areas (Parameswaran et al., 2020; Mahapatra and Inamdar 2021; Galhotra et al., 2024). CKDu has been reported at higher prevalence in parts of southern India (O'Callaghan-Gordo et al., 2019). Cases have been reported mainly in Telangana, Andhra Pradesh, Tamil Nadu, Goa, Odisha, Punjab, and Chhattisgarh (John et al., 2021). In rural areas, limited access to advanced healthcare can make treatments such as dialysis and transplantation difficult to obtain, underscoring the importance of prevention.

Although India's constitutional and legal framework recognizes the need for clean and safe water, the meaning of these terms may not always be clearly defined or consistently applied. Poor water-quality monitoring and control could further constrain preventive efforts in areas where CKDu has been reported.

CKDu has also been reported in several regions worldwide. While cases share some clinical features, differences in presentation and context across regions complicate efforts to establish a precise, universally applicable definition.

CKD is diagnosed through a clinical assessment that commonly includes blood and urine tests, with imaging and, in selected cases, a kidney biopsy. Key measures include the estimated glomerular filtration rate (eGFR) and urine albumin-to-creatinine ratio (ACR). CKD is defined by an eGFR below 60 mL/min/1.73 m², an ACR above 30 mg/g, or other markers of kidney damage that persist for at least three months (Singh et al., 2009; Chen et al., 2019).

2. Etiology, environmental factors and water quality

Numerous hypotheses have been proposed to explain the rising incidence of CKDu, including environmental, behavioural, immunity-related and genetic factors, with the former being the most discussed etiology. However, many of these hypotheses still

need to be validated. In India, one of the hypotheses regarding the causative factors related to Uddanam Endemic Nephropathy and Tondaimandalam Nephropathy include high levels of silica and heavy metals in water and high use of pesticides (Paidi et al., 2021). However, these evidences are inconclusive in nature as the cross-sectional works reported are largely based on preliminary observations with very limited samples. Therefore, there is a pressing need for research to explore water quality, especially the role of trace metals and organic contaminants, and their potential carcinogenic effects. Furthermore, the lack of baseline data on dissolved organic compounds highlights the need for extensive hydro-chemical research.

The geographical clustering of CKDu hotspots suggests its possible linkage to water quality. The lack of a comprehensive legal mechanism to ensure water quality monitoring, especially for organic contaminants, further complicates the situation. Regular water quality monitoring by the Central Pollution Control Board (CPCB), India, and Central Ground Water Board (CGWB), India typically focuses on common parameters such as hardness, pH, Electrical conductivity, total dissolved

Parameter group	Routine CGWB/CPCB monitoring	BIS IS 10500:2012	Gap
pH, TDS, total hardness	Monitored	Specified	None
EC, Na, K, HCO_3, CO_3, PO_4, SiO_2	Monitored	No limit specified	Monitored, but no health-based standard
Cl, SO_4, NO_3, F, Ca, Mg	Monitored	Specified	None
Fe, Mn, Cu, Zn, As, Pb, Cd, Ni, Cr	Reported by CGWB, but not for all stations	Specified	Incomplete monitoring
Hg, Se, Ba, Mo, Al, B, Ag, cyanide	Not reported in CGWB 2024 data	Specified	Monitoring gap
Uranium	Reported by CGWB	No limit (gross alpha/beta only)	Standard-setting gap
Pesticide residues	Not reported as routine	Specified (Table 5; 18 pesticides, no glyphosate)	Monitoring gap
Pol aromatic hydrocarbons (PAHs), Polychlorinated biphenyls (PCBs), phenolic compounds, mineral oil, trihalomethanes	Not reported as routine	Specified	Monitoring gap
Phthalates, benzene and other VOCs	Not routinely reported	Not specified	Standard-setting and monitoring gap

Table 1. *Comparison of parameters under routine groundwater and water-quality monitoring by CGWB and CPCB with those specified for drinking water in IS 10500:2012 (BIS), highlighting gaps in monitoring and standard-setting for organic contaminants relevant to CKDu research.*

solids, selected ions (CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, Ca^{2+}, Mg^{2+}, Na^+, K^+, F^-) and selected trace elements (U and As). Although IS 10500:2012 specifies limits for selected organic parameters (pesticide residues, PAHs, PCBs, phenolic compounds, mineral oil and trihalomethanes), routine groundwater monitoring by CGWB/CPCB primarily reports inorganic parameters (Table 1). Phthalates and other hydrocarbons are neither routinely monitored nor covered by a prescribed limit. The absence of baseline data on the organic chemistry of water makes it challenging to compare data from affected areas, hindering efforts to identify potential contaminants associated with CKDu.

3. Health impact, inequities in accessing health care, and social stigma related to CKDu

The primary issue in India is the lack of systematic screening for kidney disease at the community level, leading to delays in early detection and timely diagnosis. Consequently, patients often seek medical support at healthcare facilities at an advanced stage of the disease. At this late point, compromised renal function frequently leads to secondary hypertension and altered glucose metabolism, making it difficult to determine whether hypertension/diabetes was the primary driver of kidney disease or a secondary consequence of advanced renal impairment (Jolly and Thomas, 2022). This diagnostic ambiguity underscores the critical necessity of early community-level screening to accurately differentiate primary CKDu from traditional diabetic or hypertensive nephropathy before secondary complications supervene. This progression underscores the importance of early diagnosis to distinguish between CKDu and CKD. In addition, research indicates a potential link between dissolved organic compounds and the development of hypertension and diabetes, further emphasizing the need for comprehensive monitoring and research (Stallings-Smith et al., 2018; Lu and Ni, 2023). In India, the availability of dialysis and kidney transplantation facilities is grossly inadequate. According to recent statistics, India has approximately 5,000 dialysis centres, with 90% in urban areas (Billa et al., 2026). However, rural areas where CKDu hotspots are emerging often have limited access to kidney care. In 2018, an estimated 175,000 people in India were receiving chronic dialysis, while the country had only about 2,600 practicing nephrologists (Bharati and Jha, 2020). The lack of facilities exacerbates the problem, leaving many patients without access to essential treatment.

Social stigma surrounds CKD and CKDu, which might lead to underreporting and reluctance among affected individuals to seek medical help. In some areas such as Uddanam, Andhra Pradesh, India, there is reluctance observed to disclose

health issues to officials or researchers (John et al., 2021). This reluctance results in patients consulting doctors only at advanced stages of the disease, complicating diagnosis and treatment.

Addressing CKDu requires an integrated, multidisciplinary approach. Collaboration among experts in health, epidemiology, geology, chemistry, and biochemistry is essential to tackle this public health concern. For instance, research in Sri Lanka has demonstrated a decline in CKDu cases by providing Reverse Osmosis (RO) water for drinking purposes (Ranasinghe et al., 2024) suggesting that water quality plays a crucial role in the disease's prevalence. In Central America, enhanced workplace interventions for sugarcane workers (adequate purified water, rest and shade) have been associated with lower kidney injury and eGFR decline (Wesseling et al., 2020), suggesting that prevention can be effective even where the precise cause remains unresolved. Together with the Sri Lankan experience, these examples support context-specific, multi-pronged prevention strategies for India.

The emerging CKDu hotspots in India highlight a pressing public health challenge exacerbated by inadequate healthcare facilities, environmental factors, and social stigma. Addressing CKDu requires a comprehensive approach that includes improved water quality monitoring, early diagnosis, and multidisciplinary research. As a first step in the preventive direction, improving the quality of water and ensuring acceptable standards for drinking water through appropriate legal mechanisms is very important.

4. Regulating water quality: ethical and legal perspectives

The pertinent issues related to the identification of CKDu hotspots in India and its possible association with water quality parameters essentially demands an attention over ethical-legal perspectives. A significant aspect of this issue lies in the violation of fundamental rights guaranteed under the Constitution of India (Article 21)[1] along with ineffective implementation of associated legal provisions. The history of water rights discourse demanded a fundamental shift from analysing water as a 'commodity' to water as a 'social good' for addressing socio-economic disparities associated with water allocation, control, rights and use (Larrick, 2017). Despite the existence of water laws and regulation in the country, the real issue in the context is availability and accessibility of clean water for use. This is crucial on account of studies reflecting on socio-economic status of individuals and its correlation with CKDu incidence.

[1] https://cdnbbsr.s3waas.gov.in/s380537a945c7aaa788ccfcdf1b99b5d8f/uploads/2024/07/20240716890312078.pdf (accessed 26 October 2026).

India recognize the rights-based discourse on water and judicial decisions in India effectively acknowledge right to water as part of right to life which falls under Article 21 of the Constitution of India (Muralidhar 2006; Narain, 2010). This extended interpretation reiterates right to safe drinking water coupled along with right to health and right to clean and healthy environment as fundamental to human life (Wahi, 2022).

These constitutional and legal rights stand as a substantial reason for the need for ensuring water quality especially on account of rising CKDu incidence in certain hotspot areas like Tamil Nadu. The right to safe and clean water is upheld as a fundamental right and basic entitlement of people, however, the substantive content of the right is not defined or clarified. For example, although the right to water is associated with access to 'clean' and 'safe' water, these terms remain insufficiently defined across policy, regulatory, and legal frameworks. This leads to ineffective enforcement of quality controls in the country (Sharma, 2017).

The Water (Prevention and Control of Pollution) Act (1974)[2] has provided for the establishment of Pollution Control Boards at central and state level as regulatory bodies for ensuring measures for prevention, control and abatement of water pollution. The Act has not contemplated much on quality standards for water quality. World Health Organization has also prescribed guidelines for country-based adoption in its regulation and standard setting for drinking water quality (WHO, 2022). Apart from this, Bureau of Indian Standards has also prescribed the drinking water specification ISO 10500:2012[3] for ensuring water quality standards for drinking water. It is important to note that the regulatory assessment framework focuses largely on faecal coliforms, faecal streptococci, pH, dissolved oxygen, and biochemical oxygen demand. The presence of organic chemical components is relatively out of regulatory scope on account of non-inclusion of chemicals in the standards. Literature has also accounted that weak institutional framework, ineffective periodic quality assessments, ill-defined regulatory standards and updating of newly discovered chemical formulations has contributed to the weakened quality standard assessment for drinking water in India (Sharma, 2024).

5. Conclusion

From an epidemiological point of view, there is a lack of a comprehensive approach to understanding the burden of CKDu and unravelling its causes in India. The quality

[2] https://faolex.fao.org/docs/pdf/ind2085.pdf (accessed 26 October 2026).
[3] https://law.resource.org/pub/in/bis/S06/is.10500.2012.pdf (accessed 26 October 2026).

standard prescription for drinking water must be implemented with periodic updating of regulatory standards through effective assessment and continuous monitoring. The existing legal provisions should be effectively implemented and the regulatory scope needs to be widened to check for the presence of organic chemical components. Moreover, such testing requirement has to be incorporated as mandatory clauses so that Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCB) can conduct these analyses along with their routine sample analysis. In addition to this, there has to be decentralization of the water governance framework as well as adoption of measures to strengthen capacity augmentation of local self-government on standard quality assessment of drinking water. Mandating routine organic chemical profiling within CPCB and SPCB frameworks represents an urgent public health priority. Immediate state and central legislative actions are essential to establish clear regulatory timelines and enforce clean water standards to mitigate the expanding CKDu burden and shape the direction of preventive measures across rural India.

References

Bharati J. and Jha V., (2020). Global Dialysis Perspective: India. Kidney360, 1(10), 1143-1147. https://doi.org/10.34067/KID.0003982020.

Billa V., Usulumarty D., Bodke S., Kothari J., Bichu S., et al., (2026). Long-Term Survival on Hemodialysis: A Multicenter Cohort Study From India. Indian Journal of Nephrology, article in press. https://doi.org/10.25259/IJN_150_2026.

Chen T.K., Knicely D.H. and Grams M.E., (2019). Chronic Kidney Disease Diagnosis and Management: A Review. JAMA, 322(13), 1294-1304. https://doi.org/10.1001/jama.2019.14745.

Galhotra A., Rathore V., Pal R., Nayak S., Ramasamy S., et al., (2024). Clinico-Epidemiological Profile of Patients with Chronic Kidney Diseases of Unknown Etiology: A Hospital-Based, Cross-Sectional Study from Central India. Indian Journal of Nephrology, 34(3), 241-245. https://doi.org/10.4103/ijn.ijn_68_23.

Hill N.R., Fatoba S.T., Oke J.L., Hirst J.A., O'Callaghan C.A., et al., (2016). Global Prevalence of Chronic Kidney Disease – A Systematic Review and Meta-Analysis. PLoS ONE, 11(7), e0158765. https://doi.org/10.1371/journal.pone.0158765.

John O., Gummudi B., Jha A., Gopalakrishnan N., Kalra O.P., et al., (2021). Chronic Kidney Disease of Unknown Etiology in India: What Do We Know and Where We Need to Go. Kidney International Reports, 6(11), 2743-2751. https://doi.org/10.1016/j.ekir.2021.07.031.

Jolly A.M. and Thomas J., (2022). Chronic kidney disease of unknown etiology in India: a comparative study with Mesoamerican and Sri Lankan nephropathy. Environmental Science and Pollution Research, 29, 15303-15317. https://doi.org/10.1007/s11356-021-16548-w.

Larrick M., (2017). Book note: Water Wars: Privatization, Pollution and Profit. University of Denver Water Law Review, 21, 83, https://digitalcommons.du.edu/cgi/viewcontent.cgi?article=1007&context=wlr (accessed 26 October 2026).

Lu L. and Ni R., (2023). Association between polycyclic aromatic hydrocarbon exposure and hypertension among the U.S. adults in the NHANES 2003-2016: A cross-sectional study. Environmental Research, 217. https://doi.org/10.1016/j.envres.2022.114907.

Mahapatra H.S. and Inamdar N., (2021). Chronic Kidney Diseases of Unknown Etiology (CKDu) Hot Spot at Narsinghpur and Badamba Blocks in Costal Districts of Odisha, India. Indian Journal of Nephrology, 31(3), 327-328. https://doi.org/10.4103/ijn.ijn_56_20.

Muralidhar S., (2006). The right to water: An overview of the Indian legal regime. In Riedel E. and Rothen P. (eds.), The Human Right to Water. Berliner Wissenschafts-Verlag, Berlin, pp. 65-81, https://www.ielrc.org/content/a0604.pdf (accessed 26 October 2026).

Narain V., (2010). Water as a fundamental right: A perspective from India. Vermont Law Review, 34(4), 917-926, https://lawreview.vermontlaw.edu/wp-content/uploads/2012/02/narain.pdf (accessed 26 October 2026).

O'Callaghan-Gordo C., Shivashankar R., Anand S., Ghosh S., Glaser J., et al., (2019). Prevalence of and risk factors for chronic kidney disease of unknown aetiology in India: secondary data analysis of three population-based cross-sectional studies. BMJ Open, 9(3). https://doi.org/10.1136/bmjopen-2018-023353.

Paidi G., Jayarathna A.I.I., Salibindla D.B.A.M.R., Amirthalingam J., Karpinska-Leydier K., et al., (2021). Chronic Kidney Disease of Unknown Origin: A Mysterious Epidemic. Cureus, 13(8). https://doi.org/10.7759/cureus.17132.

Parameswaran S., Rinu P.K., Kar S.S., Harichandrakumar K.T., James T.D., et al., (2020). A Newly Recognized Endemic Region of CKD of Undetermined Etiology (CKDu) in South India—"Tondaimandalam Nephropathy". Kidney International Reports, 5(11), 2066-2073. https://doi.org/10.1016/j.ekir.2020.08.032.

Ranasinghe A.V., Somatunga L.C., Kumara G.W.G.P., Karunarathna R.H., De Silva A.P., et al., (2024). Decreasing incidence of hospital-diagnosed CKD/CKDu in North Central Province of Sri Lanka: Is it related to the provision of drinking-water reverse-osmosis plants? BMC Nephrology, 25. https://doi.org/10.1186/s12882-024-03534-w.

Sharma A., (2017). Drinking Water Quality in Indian Water Policies, Laws, and Courtrooms: Understanding the Intersections of Science and Law in Developing Countries.

Bulletin of Science, Technology & Society, 37(1), 45-56. https://doi.org/10.1177/0270467617738696.

Sharma A., (2024). Water Quality and Water Pollution. In Cullet P., Bhullar L. and Koonan S. (eds.), The Oxford Handbook of Environmental and Natural Resources Law in India, Oxford University Press, pp. 611-630. https://doi.org/10.1093/oxfordhb/9780198884682.013.35.

Singh N.P., Ingle G.K., Saini V.K., Jami A., Beniwal P., et al., (2009). Prevalence of low glomerular filtration rate, proteinuria and associated risk factors in North India using Cockcroft-Gault and Modification of Diet in Renal Disease equation: an observational, cross-sectional study. BMC Nephrology, 10. https://doi.org/10.1186/1471-2369-10-4.

Stallings-Smith S., Mease A., Johnson T.M. and Arikawa A.Y., (2018). Exploring the association between polycyclic aromatic hydrocarbons and diabetes among adults in the United States. Environmental Research, 166, 588-594. https://doi.org/10.1016/j.envres.2018.06.041.

Wahi N., (2022). The Evolution of the Right to Water in India. Water, 14(3). https://doi.org/10.3390/w14030398.

Wesseling C., Glaser J., Rodríguez-Guzmán J., Weiss I., Lucas R., et al., (2020). Chronic kidney disease of non-traditional origin in Mesoamerica: a disease primarily driven by occupational heat stress. Revista Panamericana de Salud Pública, 44. https://doi.org/10.26633/RPSP.2020.15.

WHO, (2022). Guidelines for Drinking-water Quality: Fourth Edition Incorporating the First and Second Addenda. World Health Organization, https://www.who.int/publications/i/item/9789240045064 (accessed 26 October 2026).

*Corresponding author: **Lekha D Bhat**

e-mail: lekhabhat@cutn.ac.in

© 2026 Istituto Nazionale di Geofisica e Vulcanologia

All rights reserved