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WATER AND HYGIENE IN THE KHARAA RIVER BASIN, MONGOLIA: CURRENT KNOWLEDGE AND RESEARCH NEEDS

ABSTRACT. The Kharaa River Basin has some of the highest densities of population, agricultural and industrial activities in Mongolia. This puts the naturally limited water resources under pressure in both a quantitative and qualitative perspective. Besides mining, key sources of surface water contamination include large numbers of livestock in riverine floodplains and the discharge of untreated or poorly treated waste waters, both into rivers and by soil infiltration. Since both shallow groundwater and river water are used by people and for livestock, there are at least theoretical risks related to the transmission of water-borne pathogens. Only a very limited number of studies on water and hygiene have so far been conducted in Mongolia, all indicating (potential) risks to water users. However, a lack of current and reliable water microbiology data leads to the need of systematic screening of water hygiene in order to derive conclusions for public health and drinking water management at the local and regional scale.

KEY WORDS: Water; hygiene; Kharaa River Basin; Mongolia

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INTRODUCTION

With a population density of only around 2.0 inhabitants/km^2 (National Statistical Office of Mongolia 2017), Mongolia is the world's most sparsely settled country. However, the combination of a highly continental climate, a growing competition for water from the agricultural, mining and urban sector, and a very uneven distribution of the population result in major water-related challenges. The Kharaa River Basin is not only one of the most densely settled areas of the country, but also characterized by intensive agriculture, livestock farming and mining activities (Karthe et al. 2016). Natural limitations in water availability are exacerbated by deficient water supply and wastewater disposal infrastructures in both urban and more rural regions (Karthe et al. 2016).

In 2000, the Mongolian government committed itself to achieving the Millennium Development Goals. With respect to water and sanitation, the plans are to achieve coverage rates of 80% for 'improved' drinking water sources and 70% for 'improved' sanitation facilities (UNDP, 2010). Current data suggest, however, that these goals may not be met, particularly in rural and peri-urban ger areas

(Sigel 2012; Uddin et al. 2014; UNDP 2010). Ger areas are low-income, partly informal settlements where people live in gers – the traditional Mongolian felt tent – and/or in simple, detached houses. Such a situation is conducive to outbreaks of water-borne diseases; however, empirical data about the microbiological water quality and the incidence of water-borne diseases is very rare.

In the context of a recent research and development project, the scientific base for an integrated water resources management (IWRM) for the Kharaa River Basin was investigated (Karthe et al. 2015a). This included comprehensive investigations of physico-chemical water quality (e.g., Hofmann et al. 2008, 2010, 2011, 2015; Menzel et al. 2011; MoMo Consortium 2009; Pfeiffer et al. 2015). However, so far the monitoring of surface, ground and drinking water did not include the question of water hygiene, despite some indications that this may be a substantial problem (Karthe et al. 2012). The aim of this paper is to synthesize the current state of knowledge on water and hygiene in the Kharaa River Basin, which is an important prerequisite for identifying research needs and planning future investigations into this topic. This paper is a meta-analysis based on existing literature and studies.

WATER AND HYGIENE IN MONGOLIA

Studies outside the Kharaa River Basin

Quality-assured data on water and hygiene is very much limited in Mongolia. In the recent past, only a few scientific studies on the hygienic quality of drinking, ground and surface water in the country has been carried out. Contrary evidence for potential bacterial contamination was found for the Selenge River into which the Kharaa River drains via the Orkhon. Whereas Sorokovikova et al. (2013) describes high concentrations of coliform bacteria, ranging between 227 and 6600 CFU/100ml in March and July 2010, respectively, Mu et al. (2008) did not find any evidence pointing towards elevated concentrations of coliforms in the Selenge River Basin (all samples analyzed by the authors were below the Russian sanitary norm of 50 CFU/100ml). Contrastingly, Sorokovikova et al. (2013) assumed domestic wastewater to a relevant source of microbiological surface water pollution, with elevated levels of fecal enterococci being another indicator. For drinking water, a recent survey on the exposure to water, sanitation and hygiene (WASH) related hazards in the peri-urban ger areas of Ulaanbaatar revealed that during the winter, 36% of the household storage containers were contaminated by E. coli at an average of 12.5 E. coli per 100 ml, which rose to 56% contaminated at an average of 50 E. coli per 100 ml in summer (Uddin et al. 2014). Additionally, a study on the health status of seminomadic pastoralists in Mongolia, who make up around one quarter of the country's total population was carried out during the early 1990s and concluded that diarrheal diseases, which were potentially water-borne, were an important cause of morbidity and mortality (Foggin et al. 1997). It is believed that the "sudden disengagement of the Mongolian state fostered the resurgence of infectious morbidity (…) in the 1990s" (Mocellin and Foggin 2008), i.e. at the beginning of the political and socioeconomic transition period following the collapse of socialism. At that time, digestive tract disorders made up between 7.9% and 18.4% of the total morbidity in Khovd, Khuvsgul and Övörhangay provinces (Mocellin and Foggin 2008).

In a review on emerging infectious diseases in Mongolia, Ebright et al. (2003) reported that the summer season is when most diarrheal diseases are reported. According to this review, about 80% of all acute hepatitis cases in Mongolia are due to the usually food- and waterborne hepatitis A virus. Moreover, the authors mention Salmonella spp. and Shigella spp. as the causative organisms of bacterial diarrhea but add that several other bacteria and viruses could not be detected in Mongolia due to a lack of equipment, laboratory consumables or experienced staff.

CURRENT KNOWLEDGE ON WATER, SANITATION AND HYGIENE IN THE KHARAA RIVER BASIN

Problems related to WASH are discussed at the example of Darkhan, which is not only the largest city in the Kharaa River Basin but also the third largest of Mongolia.

Like other major water supply companies, Darkhan's municipal service provider "Darkhan US SUVAG" (USAG) carries out culture-based tests for indicator bacteria in the drinking water before it enters the city's distribution system. Nevertheless, existing data do not necessarily provide a reliable assessment of the drinking water supplied to the city's population for several reasons: (1) laboratory facilities are inadequate; (2) distribution pipelines are in a poor state (Scharaw and Westerhoff 2011); (3) testing is typically not carried out at the consumer's tap. In smaller towns, a lack of experienced laboratory staff or long distances to the nearest water laboratory may be additional reasons why monitoring is limited.

Water provided to ger residents through pipe-fed water kiosks is officially considered to be an improved and safe source of water (Sigel et al. 2012). However, not all water kiosks (Fig. 1) are pipe-fed, and data from Ulaanbaatar show that water obtained from water kiosks is not always safe to drink from a microbiological perspective, with E. coli concentrations in 2 out of 40 water kiosk samples even exceeding 100 E. coli per 100 ml (Uddin et al. 2014). The ger areas located in the floodplains of the Kharaa River are exposed to high risks as families often use private wells for the abstraction of shallow groundwater. The quality of this water is not monitored, but the likelihood of contamination from unsealed pit latrines and animal excreta, which are partly found in close proximity to private wells, is considerable (Karthe et al. 2012; Sigel et al. 2012).

Almost nothing is known about the hygienic state of surface water in the Kharaa River. However, there are several likely sources of microbiological surface water contamination. Typical point sources of coliform bacteria and pathogens in rivers include wastewater treatment plants and sewer overflows, whereas the diffuse sources with the greatest impact is manure from grazing animals or applied as fertilizer (Reder et al. 2015).

Several wastewater treatment plants are only partly operational or completely dysfunctional, including those of Darkhan and Bayangol (Baruunkharaa) (Fig. 2), two of the largest settlements in the Kharaa River Basin. Many WWTPs were originally equipped with a disinfection stage based on chlorination. Khongor Sum is currently the only municipality where such equipment is operational (Nöh and Böttger 2013).

Fig. 1. Water kiosk in Darkhan

Fig. 2. Dysfunctional chlorination chamber, Sharyngol WWTP

High livestock densities in the floodplains (Fig. 3), and often in direct proximity to the river banks, are another potential cause of microbial water contamination (Reder et al. 2015). However, there are currently no data on either lifestock numbers at the river basin scale or data on surface water microbiology. Surface water microbiology is, however, relevant in the sense that (a) it is typically consumed by animals that live in close proximity to their herders; (b) nomadic and sedentary people living close to rivers use surface water as a drinking water source or for food preparation.

NEEDS AND OPTIONS FOR OPERATIONAL MONITORING OF WATER HYGIENE

Most countries of the world have established legal norms for the monitoring of drinking, surface and ground water, and in many cases, developing and transition countries have followed the example of industrialized countries where a combination of drinking water source protection, efficient water treatment and stringent water quality monitoring has helped to almost eliminate water-related diseases (Castell-Exner 2001; Schoenen 2002).

Regarding microbiological water quality, there are typically clear regulations for drinking water, aiming at the exclusion of any risks to public health. For this purpose, water samples are routinely monitored for indicators of fecal contamination, typically by quantifying coliform bacteria concentrations via culture-based techniques and comparing the results to drinking water standards (APHA et al. 1998; Pitkänen et al. 2007; Rompré et al. 2002). For surface and groundwater, most countries in the world do not have general microbiological quality standards, nor is there a requirement for microbiological quality monitoring (unless such sources are used for drinking or bathing) (Karthe et al. 2016b).

AVAILABLE METHODS

A small set of indicators is typically used for the basic characterization of water hygiene. Total coliforms are bacteria that are grown in or on a medium containing lactose at a temperature of 35°C or 37°C. Fecal coliform –or more correctly– thermotolerant coliform bacteria grow on lactose at a temperature of 44°C or 44.5°C. Normally, more than 95% of the thermotolerant coliforms isolated from water are Escherichia coli, i.e. fecal coliform

Fig. 3. Goats grazing on the river bank

bacteria (Bartram & Padley 1996). The use of the coliform group, and more specifically E. coli, dates from their first isolation from feces at the end of the 19th century. The coliform group includes a broad range of bacteria in terms of genus and species, and precise definition of coliform bacteria differs slightly depending on the country or organization in charge of monitoring regulations (Rompré et al. 2002).

A specific challenge in non-disinfected waters such as surface water is the background flora, which requires the use of sufficiently selective culture media. On the other hand, the analysis of drinking water requires a high level of sensitivity (Pitkänen et al. 2007). Since drinking waters are typically oligotrophic, stressed and starved cells can generate serious limitations due to false negative results or underestimations of contamination (Rompré et al. 2002).

One of the most rapid and widely used culture-based methods for quantifying both total coliform and E. coli is the commercialized Colilert system (IDEXX Laboratories Inc., Portland, ME, USA). While the system performs well for non-disinfected water samples, it may underestimate E. coli concentrations or even provide false-negative results (Pitkänen et al. 2007).

A general disadvantage of culture techniques is the time-consuming sample incubation. At present there are several alternatives or complementary options to the classical methods: flow cytometry, approaches based on RNA/DNA amplification and identification (e.g. PCR, DNA microarrays, pyrosequencing, fluorescence in situ hybridization), immunology-based methods, and biosensor-based methods (Conelly and Baeumner 2012; Ramírez-Castillo et al. 2015). A prerequisite for the detection of low levels of pathogens or indicator organisms in water samples using molecular techniques are both sample concentration steps and the implementation of a discrimination between living and dead microorganisms. Currently, there is a strong research focus on ways to combine such sample pre-treatment steps with the actual detection in automated systems (Gibson et al. 2012; Grabow et al. 2001; Hakenberg et al. 2014; Kunze et al. 2015; Langer et al. 2014).

NEEDS AND PERSPECTIVES FOR WATER HYGIENE MONITORING IN THE KHARAA RIVER BASIN

The current data scarcity about drinking, ground and surface water hygiene in Mongolia is very problematic in the context of national and water resources management planning (Karthe et al. 2015b), since it is currently difficult to assess where and if measures to improve microbial water quality are required. The so far controversial data situation regarding instream coliforms in the Selenge River and morbidity data suggest that there may be problems related to water-borne infections, and the presence of pit latrines close to shallow wells, poorly maintained wastewater treatment plants and large number of livestock in floodplains mean that ground and surface waters potentially get contaminated by harmful pathogens.

The need to improve the availability of quality-assured data on WASH risks requires a systematic survey of ground, surface and drinking water, particularly in locations that are prone to contaminations. It is suggested that such a survey is carried out in two phases: (1) an initial survey looking at total and thermotolerant coliforms as indicator bacteria, using robust and reliable field methods and (2) a more in-depth survey looking at a larger number of pathogens, potentially with more sophisticated detection methods.

Based on the current state of knowledge, an initial assessment of water hygiene in the region would cover the following locations:

- piped drinking water supply systems in major settlements (e.g. Zuunkharaa, Darkhan);
- water kiosks, particularly when they are not connected to centralized supply systems of deep wells;
- wells in floodplain areas where groundwater levels are shallow and there is a risk of contamination due to nearby livestock and/or latrines;
- surface water downstream of municipal wastewater treatment plants and ger settlements located in the floodplains; and
- surface water downstream of major livestock concentrations in the floodplains.

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REFERENCES

Anthonj, C., Beskow, S., Dornelles, F. et al. (2014). Water in Urban Regions: Building Future Knowledge to Integrate Land Use, Ecosystem Services and Human Health. Halle/Saale, Rio de Janeiro, Berlin: German National Academy of Sciences Leopoldina, Brazilian Academy of Sciences, German Young Academy, 32 p.

APHA, AWWA, AEF - American Public Health Association, American Water Works Association and Water Environment Federation (1998). Standard Methods for the Examination of Water and Waste Water, 20th ed. Washington D.C.

Batram, J. and Padley, S. (1996). Microbiological Monitoring of Freshwater. In: Bartram, J., Ballance, R. (Eds). Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes, pp. 241-269. London, UK: E&FB Spon on behalf of UNEP and WHO.

Castell-Exner, C. (2001). Das Multi-Barrieren-System: Basis für eine sichere und nachhaltige Trinkwasserversorgung. energie|wasser-praxis 10/2001, pp. 24-29.

Conelly, J.T. and Baeumner, A.J. (2012). Biosensors for the detection of waterborne pathogens. Annals of Bionanalytical Chemistry Vol. 402(1), pp. 117–127. doi:10.1007/s00216-011-5407-3

Ebright, J., Altantsetseg, T. and Oyungerel, R. (2003). Emerging Infectious Diseases in Mongolia. Emerging Infectious Diseases, Vol. 9(12), pp.1509-1515.

Foggin, P. , Farkas, O., Shiirev-Adiya, S. and Chinbat, B. (1997). Health Status and Risk Factors of Seminomadic Pastoralists in Mongolia: A Geographical Approach. Social Science and Medicine, Vol. 44(11), pp. 1623-1647. DOI:10.1016/S0277-9536(96)00273-0

Gibson, K. , Schwab, K., Spencer, S. et al. (2012). Measuring and mitigating inhibition during quantitative real time PCR analysis of viral nucleic acid extracts from large-volume environmental water samples. Water Research, Vol. 46(13), pp. 4281–4291. DOI: 10.1016/j.watres.2012.04.030

Grabow, W., Taylor, M. and de Villiers, J. (2001). New methods for the detection of viruses: call for review of drinking water quality guidelines. Water Science and Technology, Vol. 43(12), pp.1–8.

Hakenberg, S., Hügle, M., Meyer, P., Behrmann, O. et al. (2014). Fenton fragmentation for faster electrophoretic on chip purification of amplifiable genomic DNA. Biosensors and Bioelectronics, Vol. 67, pp. 49-52. DOI:10.1016/j.bios.2014.06.003

Hofmann, J. (2008). Bericht über die Untersuchungen von Grundwasser und Boden auf Schwermetalle und Cyanid in Khongor Sum. DOI: 10.13140/2.1.4306.5928

Hofmann, J., Hürdler, J., Ibisch, R. et al. (2011). Analysis of Recent Nutrient Emission Pathways, Resulting Surface Water Quality and Ecological Impacts under Extreme Continental Climate: The Kharaa River Basin (Mongolia). International Review of Hydrobiology, Vol. 96 (5), pp. 484-519. DOI:10.1002/iroh.201111294

Hofmann, J., Venohr, M., Behrendt, H. et al. (2010). Integrated water resources management in central Asia: nutrient and heavy metal emissions and their relevance for the Kharaa River Basin, Mongolia. Water Science and Technology, Vol. 62(2), pp. 353-363. DOI: 10.2166/wst.2010.262

Hofmann, J., Watson, V., Scharaw, B. (2015). Groundwater quality under stress: contaminants in the Kharaa River basin (Mongolia). Environmental Earth Sciences, Vol. 73(2), pp. 629-648. DOI: 10.1007/s12665-014-3148-2

Karthe, D., Heldt, S., Houdret, A. et al. (2015a). IWRM in a country under rapid transition: lessons learnt from the Kharaa River Basin, Mongolia. Environmental Earth Sciences, Vol. 73(2), pp. 681-695. DOI:10.1007/s12665-014-3435-y

Karthe, D., Heldt, S., Rost, G. et al. (2016a). Modular Concept for Municipal Water Management in the Kharaa River Basin, Mongolia. In: Borchardt D, Bogardi J, Ibisch R (Ed). Integrated Water Resources Management: Concept, Research and Implementation, pp. 649-681. Heidelberg, Germany & New York, USA: Springer.

Karthe, D., Hofmann, J., Ibisch, R. et al. (2015b). Science-Based IWRM Implementation in a Data-Scarce Central Asian Region: Experiences from a Research and Development Project in the Kharaa River Basin, Mongolia. Water , Vol. 7(7), pp. 3486-3514. DOI:10.3390/w7073486

Karthe, D., Lin, P. and Westphal, K. (2016b). Spatial pattern of surface water hygiene at the Holtemme: Investigations in a small catchment with a strong landuse and pollution gradient. In: Chifflard, P., Heller, K., Karthe, D. (Ed). Beiträge zum 47. Jahrestreffen des Arbeitskreises

Hydrologie vom 19.-21. November 2015 in Dresden. Augsburg: Geographica Augustana.

Karthe, D., Sigel, K., Scharaw, B. et al. (2012). Towards an integrated concept for monitoring and improvements in water supply, sanitation and hygiene (WASH) in urban Mongolia. Water & Risk, Vol. 20, pp. 1-5.

Kunze, A., Pei, L., Elsaesser, D. et al. (2015). High performance concentration method for viruses in drinking water. Journal of Virological Methods, Vol. 222, pp. 132–137. DOI:10.1016/j.jviromet.2015.06.007

Langer, M., Wolf, C., Sorge, H. et al. (2014). Forschung für die Wasserinfrastrukturen von morgen. Energie|wasser-praxis 10/2014, pp. 72-75.

Menzel, L., Hofmann, J. and Ibisch, R. (2011). Untersuchung von Wasser- und Stoffflüssen als Grundlage für ein Integriertes Wasserressourcen – Management im Kharaa-Einzugsgebiet (Mongolei). Hydrologie und Wasserbewirtschaftung, Vol. 55(2), pp. 88-103.

Mocellin, J. and Foggin, P. (2008). Health Status and geographic mobility among semi-nomad pastoralists in Mongolia. Health & Place, Vol. 14(2), pp. 228-242. DOI:10.1016/j.healthplace.2007.06.005

MoMo Consortium (2009). Integrated Water Resources Management for Central Asia: Model Region Mongolia (MoMo). Case Study in the Kharaa River Basin. Final Project Report.

Mun, Y., Ko, I., Janchivdorj, L. et al. (2008). Integrated Water Management Model on the Selenga River Basin – status survey and integration (Phase I). Seoul, South Korea: Korea, Environmental Institute. Project report.

National Statistical Office of Mongolia (2017).

Nöh, C., Böttger, S. (2013). MOMO Project—Sub-Project "Waste water disposal for 6 municipalities of the Kharaa River catchment area": research report. tilia Umwelt GmbH, Leipzig. Unpublished report.

Pfeiffer, M., Batbayar, G., Hofmann, J., Siegfried, K., Karthe, D. and Hahn-Tomer, S. (2015). Investigating arsenic (As) occurrence and sources in ground, surface, waste and drinking water in northern Mongolia. Environmental Earth Sciences, Vol. 73(2), pp. 649-662. DOI: 10.1007/s12665-013-3029-0

Pitkänen, T., Paakkari, P., Miettinen, I.T. et al. (2007). Comparison of media for enumeration of coliform bacteria and Escherichia coli in non-disinfected water. Journal of Microbiological Methods, Vol. 68, pp. 522–529. DOI: 10.1016/j.mimet.2006.10.007

Ramírez-Castillo, F.Y., Loera-Muro, A., Jacques, M., et al. (2015). Waterborne pathogens: detection methods and challenges. Pathogens Vol. 4(2), pp. 307–334. doi:10.3390/pathogens4020307

Reder, K., Flörke, M. and Alcamo, J. (2015). Modelling historical fecal coliform loadings to large European rivers and resulting in-stream concentrations. Environmental Modelling & Software, Vol. 63, pp. 251–263. DOI:10.1016/j.envsoft.2014.10.001

Rompré, A., Servais, P., Baudart, J. et al. (2002). Detection and enumeration of coliforms in drinking water: current methods and emerging approaches. Journal of Microbiological Methods,Vol. 49(1), pp. 31-54. DOI: 10.1016/S0167-7012(01)00351-7

Scharaw, B. and Westerhoff, T. (2011). A leak detection in drinking water distribution network of Darkhan in framework of the project Integrated Water Resources Management in Central Asia, Model Region Mongolia. In: Гуринович АД (Ed.) (2011). Proceedings of the IWA 1st Central Asian Regional Young and Senior Water Professionals Conference, Almaty/Kazakhstan, pp. 275-282.

Schoenen, D. (2002). Role of disinfection in suppressing the spread of pathogens with drinking water: possibilities and limitations. Water Research, Vol. 36(15), pp. 3874–3888. DOI: 10.1016/S0043-1354(02)00076-3

Sigel, K., Altantuul, K. and Basandorj, D. (2012). Household needs and demand for improved water supply and sanitation in peri-urban ger areas: The case of Darkhan, Mongolia. Environmental Earth Sciences, Vol. 65(5), pp.1561-1566. DOI: 10.1007/s12665-011-1221-7

Sorokovikova, L., Popovskaya, G., Tomberg, I. et al. (2013). The Selenge River Water Quality on the Border with Mongolia at the Beginning of the 21st Century. Russian Meterology and Hydrology, Vol. 38 (2), pp.126-133.

Uddin, S., Zifu, L., Gaillard, J. C. et al. (2014). Exposure to WASH-borne hazards: A scoping study on peri-urban Ger areas in Ulaanbaatar, Mongolia. Habitat International, Vol. 44, pp. 403-411. DOI:10.1016/j.habitatint.2014.08.006

UNDP (2010). Country Sector Assessments. UNDP GoAL WaSH Programme. Vol. 2: Governance, Advocacy and Leadership for Water, Sanitation and Hygiene. New York, USA.

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