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Short Communication

Modified Kanchan arsenic filters in Nepal: The current key factor to combat the arsenic crisis

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Abstract
Ground water used as drinking water poses a serious health threat in many countries in South East Asia. Many of the districts in the lowlands of Nepal are affected by the arsenic contamination of the ground water. The most widely used filter to eliminate As and to make the water potable is the so called Kanchan filter (KAF) well know for its efficiency, affordability and easy maintenance. Some recent surveys revealed that several of these filters have a rather poor performance, alternatives have been proposed but are far from being suitable for the needs of the population in Nepal as their development is time consuming and laborious. A modified KAF version is presented here with excellent results concerning efficiency. Beyond that, the modified filters can still be produced using local material exclusively.
Keywords: *Arsenic, iron, Kanchan filter, removal, modification*

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I. Introduction

Since my first review written about arsenic in groundwater in Nepal and its mitigation options[1]several reviews or potential solutions regarding the evaluation, enhancements of the unsatisfactoryeffectiveness or modifications of the Kanchan filters widely used in the southern lowlands of Nepal have been published[2-10].Arsenic is notoriously known to contaminate groundwater in the lowlands of Nepal and to cause adverse health effects there (see[1]and references therein).

Till this day the award-winning Kanchan Arsenic Filter (KAF, a single household filter) is widely used in rural Nepal to combat this problem[11, 12].The KAF was explicitly constructed using locally available labor and materials and wasoptimized based on the local socio-economic conditions. As Timalsina et al.[9]state correctly, those filters still stand ahead in terms of efficiency, affordability, operation and maintenance. However, some recent studies have revealed a casual poor performance of these filters in Nepal and modifications of these filters were described[2, 13-16].However, suggestions from other authors concerning improvement or alternatives to the KAF were solely based on laboratory studies and did not involve any field work in the Terai including an assessment of locally available material and industrial resources to produce the filters, manpower, affordability or maintenance. These latter points will be addressed in this short communication.

II. Discussion

More or less concomitant with Ngai et al.[11,12],Hassam and Munir[17]published a study about a simple and effective arsenic filter based on composite iron matrix used in Bangladesh. This filter type was designed with a specially manufactured composite iron matrix (CIM, a mass made of cast iron turnings) and including a flow controller.This cast iron turnings are locally available in Bangladesh but cannot be found in Nepal. The use of locally available material is imperative in order to keep the cost of a filter affordable for the users. Therefore, rusty, non-galvanized nails of a small size (obtainable by local retailers in the Terai) were incorporated as the adsorbing material of choice in Nepal.Furthermore,the reactive material used in the filters in Bangladesh is constantly immersed in water in order to ensure proper corrosion. As Huang et al.[7]state appropriately "The first design mistake of the KAFdevice is certainly the existence of a non-immersed Fe^0unit which creates a dry/wet cycle for the iron nails. This is counter-intuitive in a context where long-term increased iron corrosion is needed for As removal." This dry/wet cycles also caused siderite ($FeCO_3$) to be formed on surface of the nails[18].This carbonate is precipitated under reducing conditions and indicate that oxidation does not take place and it "seals" the surface of the nails preventing As to be adsorbed[14].

To overcome the latter inadequacy, Mueller and Hug[13]already describedclearly the upcoming measures to improve the efficiency of the Kanchan filters: (1) Placement of an upper top layer of sand in order to ensure an undisturbed nail bed; (2) Uplift of the water level by raising the outlet of the filter above the level of the nail bed to assure the immersion of the nails in water constantly; (3) Monitoring of the filters to determine the functionspan of the material used (e. g. nails and sand of the lower sand bed).

The arsenic contamination of ground water in Nepal and elsewhere is undoubtedly of geogenic origin (see[19]).Karki et al.[10]borrowed the idea published in[19]and it has to be stressed at this point that adverse geological incidences affect the operation of the KAF. Concerning the unlikeefficiency of the filters used in Bangladesh and Nepal the moststriking geological feature is the low average molar Fe/As ratioin Nepal compared to Bangladesh. This number varies between 6.0 to 9.4 in Nepal whereas the ratio is as high as 90 in Bangladesh[13]. The removal efficiency of the KAF over time correlates strongly with the total iron in the ground water as this Fe forms additional adsorptive iron-phases in the filters (see e. g.[20]). The geological cause of this extremely low molar ratio Fe/As was described[19], as the catchment area of the Narayana river (the main source of the sediments transported and deposited in the province of Nawalparasi) is found in the surroundings of the Manaslu Himalaya in the province of Gorkha. In this surroundings the most prominent rocks are comprised of leucogranites and the relationship between the trace elements analyzed in the groundwater in the Terai and these elements found in such felsic rocks reflect the origin of the arsenic in the high Himalayas of Nepal. The high concentration of As and lithophile elements like Li, B, P, Mn, Br, Sr and U in the groundwater point to a felsic initial source like metapelites or leucogranites - all rocks showing a high abundance of B, P and As beside Cd and Pb.

Due to unforeseen global circumstances, 20 completely modified new KAF could only be installed in the province of Nawalparasi (Nepal) in spring 2021. Fig. 1 depicts an old filter with the outlet lower than the nail bed (red filter) as well as the filter filled with new material (nail and sand) and a higher outlet (blue filter).An upper sand bed was applied in order to avoid the nails to dry out and to keep them in place.These filters were closely monitored and water samples (ground water, water after nailbed and filtered water) were taken repeatedly for one year.The newly installed filters were working perfectly and independently of the arsenic concentration of the ground water filtered As below the WHO guideline of 10 µg/l. The majority of the filters still eliminated As below the WHO guideline according the analyses of July and November 2021. The others were still capable of filtering As to less than 50 µg/ - the interim guideline in Nepal. Analyses from April 2022 are currently evaluated and the results of this one-year-monitoring will be published in detail shortly. As Mueller and Hug[13]already stated, it is imperative the replace the lower fine sand bed every year as the intake capacity of this sand is crucial in order to achieve satisfying elimination results as the declining removal efficiency of some of the KAFs installed in April 2021 is clearly related to the decreasing filtering function of the lower sand bed.

III. Conclusions

As already stated, the actual solution of choice concerning removal of As from ground water in the lowlands of Nepal is the installation of the delineatedand modified KAF.Other As removal technologies are highly desired but taking the time consuming and laboriousdevelopment into account, the modified KAF will be in use for a long time and a close monitoring is still required. This monitoring is guaranteed from the author of this paper for the next few years.

Another issue so far not discussed in depth for other As removal technologiesis the proper storage or disposal of the material to be replaces regularly. Sand from the KAFs will be used for concrete production, the nails can be used for industrial purposes or as filling material in concreate.

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Figure 1. KAF with the outlet lower than the nail bed (red filter, old system) as well as the modified version of aKAF with the higher outlet (blue filter). Photo: B. Mueller, 9.4.2021.