Barbara Mueller. International Journal of Engineering Research and Applications
www.ijera.com
ISSN: 2248-9622, Vol. 13, Issue 9, September 2023, pp 266-277

RESEARCH ARTICLE OPEN ACCESS

Modified Kanchan filters in Nepal – A success concerning removal efficiency related to the geological background

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ABSTRACT
As in many countries in South Asia, including Nepal, the concentration of arsenic in groundwater used as drinking water frequently exceeds the World Health Organization (WHO) drinking water guideline of 10 μg/L. The groundwater is hosted in Quaternary alluvial sediments and the largely accepted explication is based on the reductive dissolution of Fe-bearing minerals releasing As-oxyanions from the soil minerals. Though, this model is only applicable to some extent in the lowlands of Nepal. Arsenic and iron in the groundwater are hardly correlated or decoupled and iron(III) (hydr)oxides are scarcely present, leading to the premise that a major portion of As and Fe has to be retained in clay minerals. This special setting has a severe impact on the As removal efficiency of the of Kanchan Arsenic Filters (KAFs) used to eliminate As from groundwater in Nepal. As there is a lack of sufficient Fe in groundwater, with a subsequent limited release of iron necessary for the corrosion of iron nails, a call for an adapted version of these filters was required. The very first results from 20 modified filters clearly indicate an substantila increase in As removal, accomplished mainly by regular replacement of used nails and fine sand as well as an elongation of the outlet tube to avoid wet−dry cycles and to keep the nail bed immersed.
Keywords – Nepal, arsenic, Kanchan filter, modification

Date of Submission: 15-09-2023 Date of acceptance: 30-09-2023

I. INTRODUCTION

The so-called Kanchan filters (iron-assisted bio-sand filters) are nowadays the first choice to remove As (mainly as As(III)) in the Terai district of Nawalparasi in Nepal. These filters representing a point-of-use drinking water treatment option were originally designed by Dr. David Manz of the University of Calgary, Canada in the late 1990 and subsequently introduced and checked in Nepal by Massachusetts Institute of Technology (MIT) researchers; ENPHO, Nepal; Rural Water Supply and Sanitation Support Programme (RWSSSP), Nepal; and CAWST, Canada, based on slow sand filtration and iron hydroxide adsorption principles [1]). The filters were constructed in order to remove arsenic from water using zero-valent iron (ZVI) media. The main As removal mechanism is based on the spontaneous adsorption and coprecipitation of As with iron(II) and iron(III) oxides/hydroxides, formed in-situ during ZVI oxidation (corrosion). As arsenic-loaded iron particles from the nailbed in the KAF are flushed down to the sand layer below and are trapped there. The major reason why Kanchan Arsenic Filters (KAF) were installed in Nawalparasi is their clear advantage using locally available labor and materials and optimizations on the local socio-economic conditions.

As described in [2], the removal efficacy of the KAFs in field conditions operating for a certain period has been barely observed. The authors of [3] suggested that the iron nails can last 3 years before replacement is necessary taking the operation under the water quality conditions encountered in the Terai region of Nepal (total arsenic <500mg/L. phosphate < 2 mg/L, pH < 8) into account. But Ngai and co-workers [3] also perceived a drop in performance over time and therefore it seemed warranted to investigate to overall performance of the KAFs thoroughly. Moreover, the drinking water guideline of 10 μg/L for arsenic introduced by the World Health Organization (WHO) was frequently exceeded in the Terai even after filtration. For ample information about the mode of operation of KAFs refer to [4-7].

Nepal is by far not the only country affected by arsenic contamination of groundwater, this issue is unfortunately very common in other South East Asian countries (Bangladesh, India, China, Vietnam, Cambodia, Myanmar and others). Groundwater of all districts of the lowland of

Nepal (Terai) as well as four hill districts exhibit an increased concentration of As, causing various detrimental health effects by intake of As from the groundwater used as potable water. Long-term exposition to elevated As concentration in drinking water can lead to skin lesions, pigmentation changes, keratosis of palms and soles and severe cancer of skin and internal organs [8-11].

Nowadays, there is a wide agreement among concerned scientists that the arsenic contamination of groundwater is of geogenic origin. The source of As seems to be clear as well: The toxic elements is derived from the natural weathering of minerals and rocks of the Himalayan belt [4, 11-15]. The Himalayan foreland basin and the Bengal fan are built up by sediments transported and deposited by the enormous Ganga–Brahmaputra river system. These sediments being deposited in regions of low elevation and exhibiting a low hydraulic gradient are specific for many arsenic-rich aquifers. Arsenic is often found in a near crustal abundance of 1–20 mg/kg in these sediments and this content can already cause a high dissolved As load (> 50 µg/L) in groundwater, particularly if one of both of the two major triggers are initiated: an rise in pH above 8.5 or the initiation of reductive iron dissolution [16-18]. Even the theory of reductive dissolution of As-rich Fe oxyhydroxides (as dispersed phase e. g. as coating on sedimentary grains) including microbial degradation of organic matter is widely accepted [e. g. 18], the geochemical situation in the Terai of Nepal is debatable: As the iron concentration in the groundwater is much lower in Nepal than, for instance, in Bangladesh or Vietnam [19] and As is hardly ever negatively or not all correlated with Fe concentration (decoupling of As, see also [18] but positively corelated with lithophile elements, such as Na and K, alumosilicates (such as clay minerals) have to be taken into account as host minerals of As. Not to mention the efficient adsorption of As onto fine-grained alumosilicates [21-24].

The aim of this study and the evaluation of the drop in performance of the Kanchan filters and the subsequent improvement of the design of this long lasting filters with regard to the special geogenic situation the Terai region of Nepal being more proximate to the high Himalayan range and therefore to the origin of the arsenic than any other of the concerned countries in South East Asia. Even tough several research articles about newly developed adsorbing material for removal of arsenic from groundwater have been proposed after laboratory testing, those sorbents are still far from being tested in field trails [see e. g. 25-27]. Given these circumstances, further development of the Kanchan filter is essential. This holds especially true concerning the rural, not industrialized context of the Terai region of Nepal where it turns out to be extremely demanding to produce sophisticated removal material. Due to local socio-economically constraints the affordability for all households has to be guaranteed further.

II. STUDY SITE, MATERIALS, AND METHODS

Samples of groundwater, water filtered after nailbed and completely filtered water used for various studies including this research carried out with modified and reconstructed Kanchan filters were collected directly from privately owned hand pumps in the urban area of Ramgram (the capital of Nawalparasi) or in the villages of Manari, Panchanagar, Tilakpur, and Unwach. The depths of the tube wells are generally 25 m and the soil of these horizon is mainly composed of clays sediments. As a consequence of the mentioned malfunction of some of the Kanchan Arsenic Filters (KAF, iron-assisted bio-sand filters) installed in the early 2000s [3, 28], Nagi and co-workers [3, 28], from the Centre for Affordable Water Sanitation Technology (CAWST), Calgary, Canada, in cooperation with the Environment and Public Health Organization (ENPHO), Kathmandu, Nepal, and Eawag, Switzerland, begun sampling campaigns for groundwater in Nawalparasi in October 2015, which continued onward. All eligible households for the sample collections were denoted according a register provided by ENPHO for the wells with filtered water exceeding the Nepal drinking water quality standard value (50 µg/L). All water samples were filled into 4.5 mL pre-acidified polypropylene vials (containing 150 µl 1M HNO_3) and were sent in a in cooler box to Eawag by courier for further examination. For chemical analyses, the acidified samples were diluted 1:5 and 1:20 into 0.1M HNO_3 for ICP-MS analysis (Agilent 7500cx). Standards for the reported elements were prepared by dilution of J.T. Baker single element standards with 0.1M HNO_3, in turn covering the relevant concentration ranges of the samples. Triplicate analysis always agreed to within 2-5%. The reported averages were multiplied with 1.033 to correct for the small dilution by the acid in the sample vials. Detection limits were at least 10 times lower than the lowest measured concentrations for all elements, except for P, B, and Fe, for which they were 0.03 mg/L, 5µg/L, and 0.03 mg/L, respectively, with dilutions of 1:5. Broad information concerning the procedures were published elsewhere [6-7, 19].

Sampling campaigns for the actual study were carried out in April 2021, July 2021, November 2021 and April 2022 in order to monitor filter efficiency in dependence on the aging of the reactive material.

III. Results and Discussion

Fig. 1 shows the modified filter. Based on observations during pre-monsoon and post-monsoon seasons [see 6-7, 19, 29], 20 modified filters were rebuilt and evaluated. The modification include: 1. An upper sand layer below the brick chips, the sand and nailbed was separated with a cloth in order to facilitate cleaning. Moreover, the flow rate was decreased this way the contact time with the nails was increased this way. 2. The outlet tube was extended and raised to above the level of the nail bed to ensure that the nails were constantly covered with water and to avoid dry-wet cycles. These major modifications were considered necessary as there is only a minor release of Fe from sediments into the groundwater (the lack of sufficient Fe in the source water hindering the efficient removal of As) as well as the known decoupling between the concentrations of Fe an As in the groundwater. The Kanchan filters were once constructed on the basis of As elimination from water by zerovalent iron (ZVI) media. The iron nails are the primary source of Fe, as removal take place by oxidation, adsorption and coprecipitation during the corrosion of the nails leading As to incorporated into iron(II,III)(hydro)oxides. The previous research clearly pointed out that the removal efficiency concerning As was fundamentally determined by the Fe concentrations in the source water instead by the meant corrosion of the iron nails [see 6-7, 19, 29]. The dependence of the removal efficiency from the aging nails is clearly indicated in Fig. 2. There is a strong correlation coefficient for the old filters analyzed in April 2021. This correlation disappears for the now filters but reappears significantly after one year of use.

The achieved removal efficiencies after complete filtration are indicated in table 1. The denotation of the filters was used according to a register provided by ENPHO Kathmandu. The newly installed Kanchan filters exhibited a remarkably increased filtration performance compared with the old filters (partly in use for more then 10 years without any replacement of the reactive material). For most of the 20 new filters the final As concentration was lower then 10 µg/l (WHO guideline of arsenic in drinking water) and for the rest the final As concentration was lower than 50 µg/l (the Nepali interim standard).

Fig. 3 provides all removal data including removal rates after nail bed, after sand bed and overall removal rates (completed filtration, groundwater now ready to use as drinking water) including all results from sampling campaigns in April 2021, July 2021, November 2021 and April 2022 as a graphic representation. The most important observation is the eminent improvement of the removal efficiency from the old filters (blue bars) to the newly installed filters (green bars). As mentioned above, the WHO guideline of 10 µg/l for drinking water was met by 15 out of 20 new filters, with the others achieving As concentrations below the Nepali interim standard of 50 µg/l. These promising results clearly point out the necessity of replacing the reactive filter material (nails and sand) on a regular basis. Filter SN45 was not in use anymore since 2016 due to a broken plastic bucket. A new filter was installed in April 2021 and the results of the groundwater analyses clearly indicated a decline in concentrations of Fe and As, thus revealing an enormous heterogeneity of the composition of the alluvial sediments and the corresponding groundwater flow [see 6, 11, 19, 30 - 31]. Most of the filters were yet working satisfactorily in July 2021 (monsoon time) still showing final As concentrations <50 μg/L. Continuing analyses from November 2021 to April 2022 clearly indicated declining removal efficiency over time, especially in filters SN57, SN64, SN66, SN69, and SN70 with a high feed of As. The final As concentration from filters SN51, SN56, SN64, SN66, SN68, SN69, SN70, and SN73 increased to above the 50 µg/L limit. Substitution of the lower sand bed immediately led to an immediate improvement of the overall removal efficiency below 27 µg/L.

As pointed out a published study, arsenic concentrations after complete treatment could be higher than those just after filtration through the nail bed only [6]. This fact is a clear evidence that the fine sand of the lower sand bed has to be replaced in regular intervals to ensure elimination of exfoliated particles from the upper nail bed, as such particles are able to release As again. In addition, the removal capacity of the lower sand bed can compensate for a low removal efficiency in the nail bed itself. As shown in Fig. 3 the removal capacity of the nail bed is declining with increasing usage and therefore the nails have to be replaced on an annual basis as well. Field observations (e. g. filters SN1A and SN65 in April, July, and November 2021 as well as SN4C in April 2022) led to the conclusion that the mass, size, and distribution of the nails are major factors for performance as the most efficient filter contained small, bright brown, rusty, and loosely kept nails. Poor performers, such as SN70 (high in As) of SN66, showed an uneven surface of the nail bed or nails glued together leading to clogged flow channels prohibiting the contact with the nails.

IV. Conclusions

Major improvements concerning removal efficiency of the Kanchan filters were achieved by regular replacement of old nails and fine sand in the lower sand bed; addition of an upper sand layer above the nail bed as well as the elongation of the outlet pipe. This way the nails were no longer displaced and were kept wet during no-flow periods. The low Fe concentrations and molar ratios of Fe/As in the groundwater in the Terai of Nepal were compensated by enhanced corrosion as a result of the constant immersion of the nails. The first result on the As removal of 20 completely rebuilt Kanchan filters in April 2021 are promising.

Considering the rural context of the Terai region of Nepal, should remain simple, straightforward and affordable. Hence, local production as to be continued as the existing filters' maintenance is elementary and operation is self-explanatory.

Acknowledgements

The author's gratitude for the support and valuable discussions is expressed to Tommy Ngai and Candice Young-Rojanschi from CAWST, Calgary, Canada; Bipin Dangol and Hari Boudhatoki from ENPHO, Kathmandu, Nepal; Gyan Prakash Yadav, Parasi; and Som Rai, the loyal expedition and trekking guide in Nepal, who was responsible for all research logistics. The author also thanks Thomas Ruettimann and Mike Chang, for the ICP-MS analysis of the samples.

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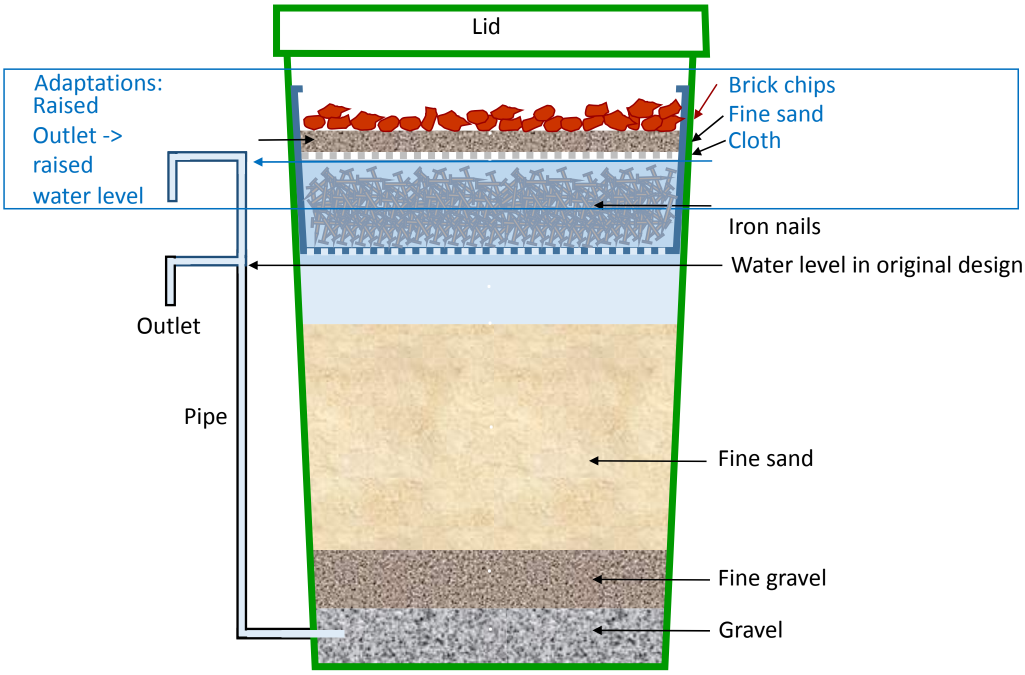


Figure 1. Diagram of the modified Kanchan filter, showing the location and arrangement of its components.

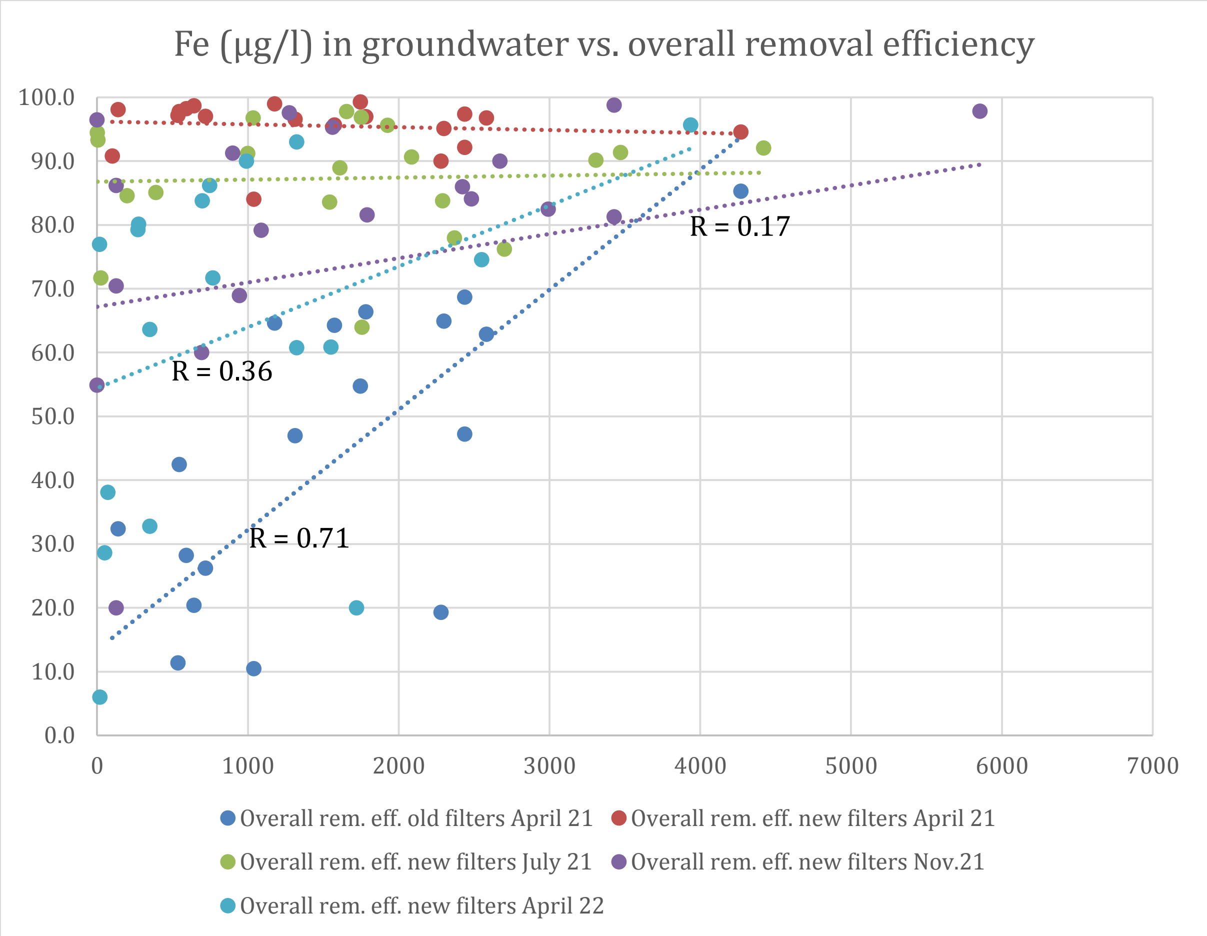
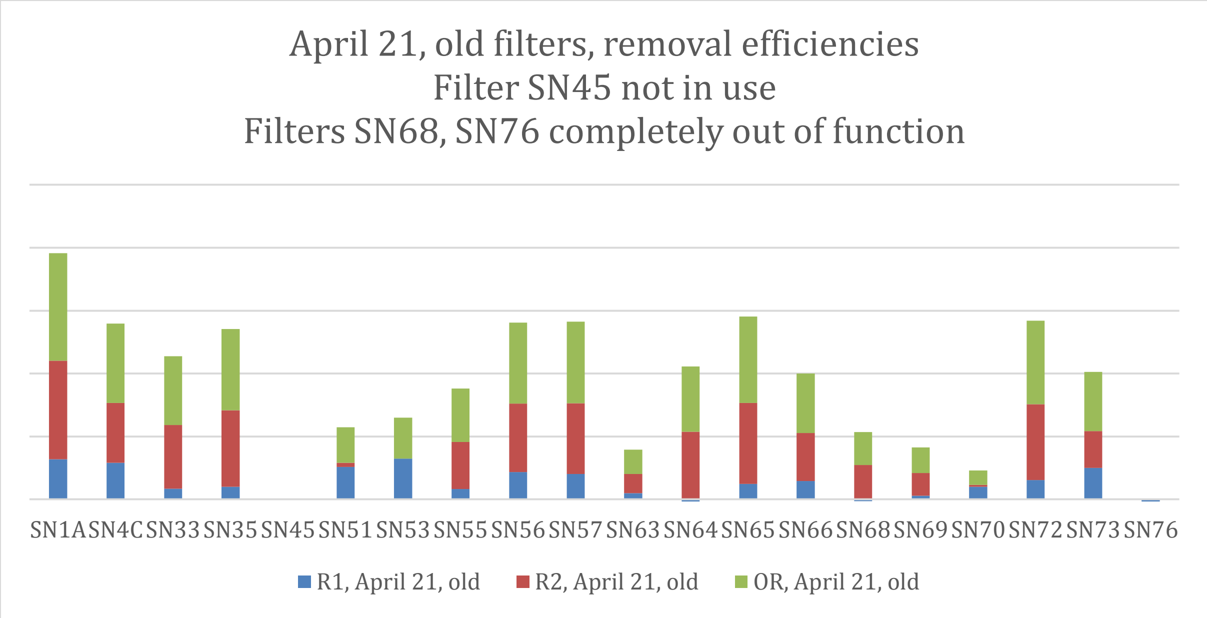
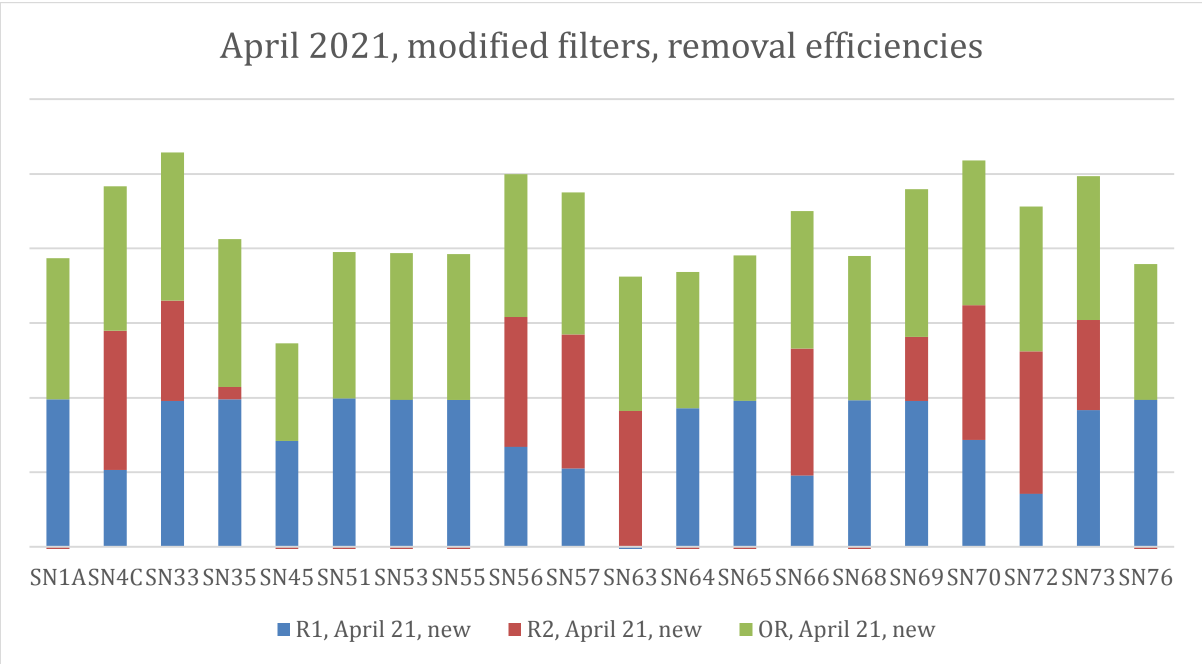
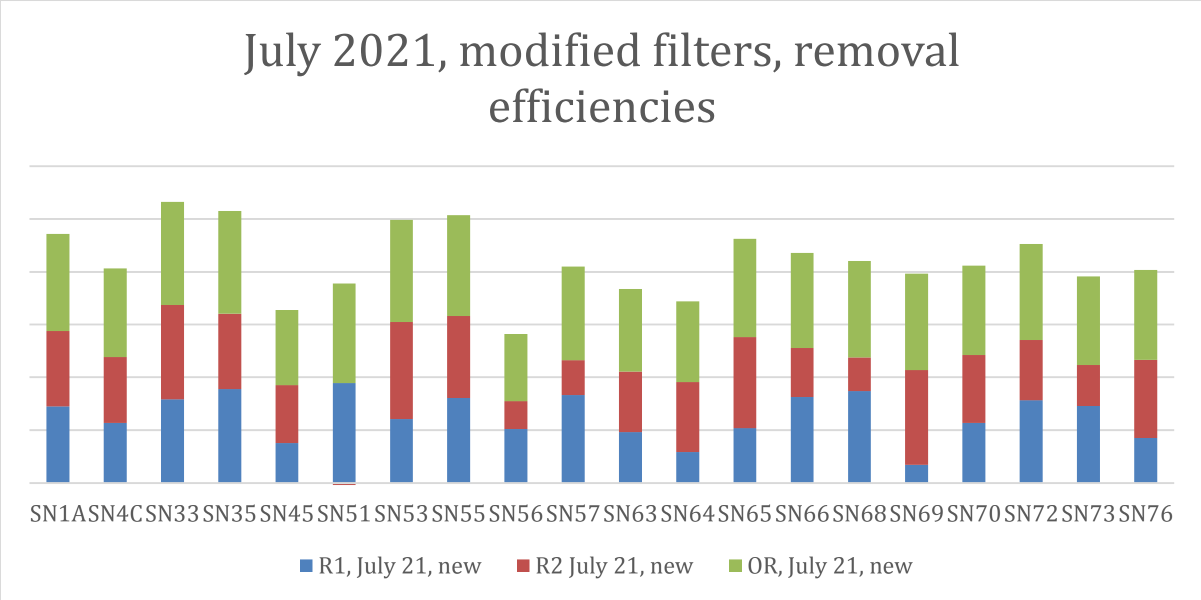
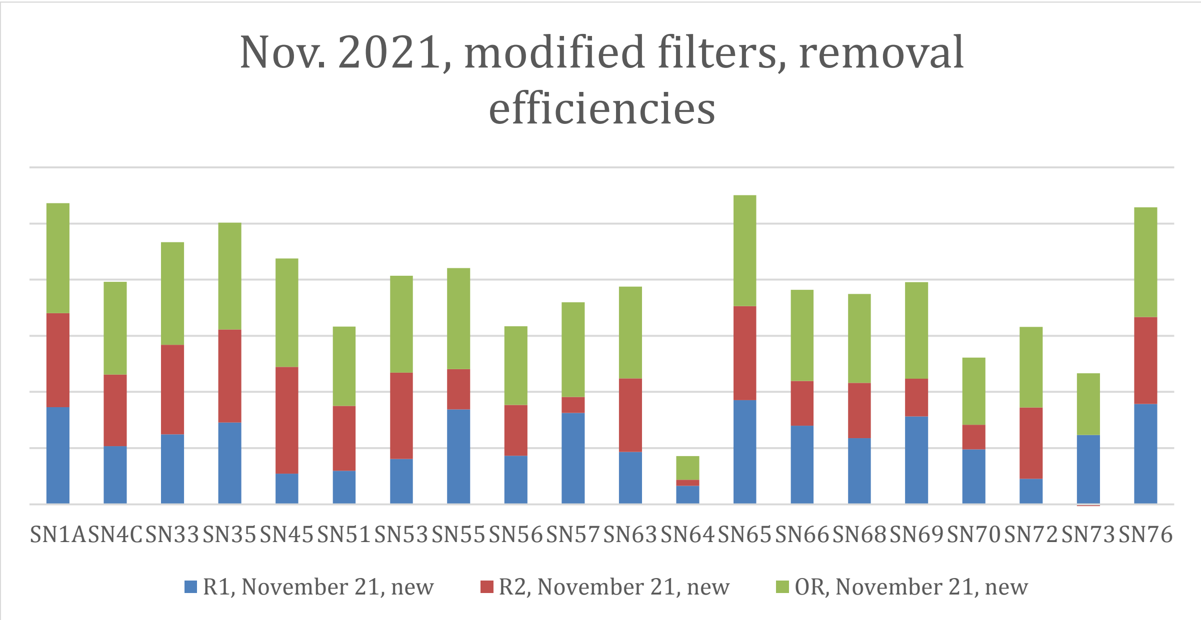


Figure 2. Dependence of the overall removal efficiency (rem. eff., filtration through nail and sand bed) from the iron concentration in groundwater. Data for the old filters (analyses from April 2021) indicate a significant correlation of the removal efficiency from the aging nails. This correlation reappears after one year of use (data from April 2022).


April 21, old filters, removal efficiencies
Filter SN45 not in use
Filters SN68, SN76 completely out of function
SN1A SN4C SN33 SN35 SN45 SN51 SN53 SN55 SN56 SN57 SN63 SN64 SN65 SN66 SN68 SN69 SN70 SN72 SN73 SN76
R1, April 21, old
R2, April 21, old
OR, April 21, old


April 2021, modified filters, removal efficiencies
SN1A SN4C SN33 SN35 SN45 SN51 SN53 SN55 SN56 SN57 SN63 SN64 SN65 SN66 SN68 SN69 SN70 SN72 SN73 SN76
R1, April 21, new
R2, April 21, new
OR, April 21, new


July 2021, modified filters, removal efficiencies
SN1A SN4C SN33 SN35 SN45 SN51 SN53 SN55 SN56 SN57 SN63 SN64 SN65 SN66 SN68 SN69 SN70 SN72 SN73 SN76
R1, July 21, new
R2 July 21, new
OR, July 21, new


Nov. 2021, modified filters, removal efficiencies
SN1A SN4C SN33 SN35 SN45 SN51 SN53 SN55 SN56 SN57 SN63 SN64 SN65 SN66 SN68 SN69 SN70 SN72 SN73 SN76
R1, November 21, new
R2, November 21, new
OR, November 21, new

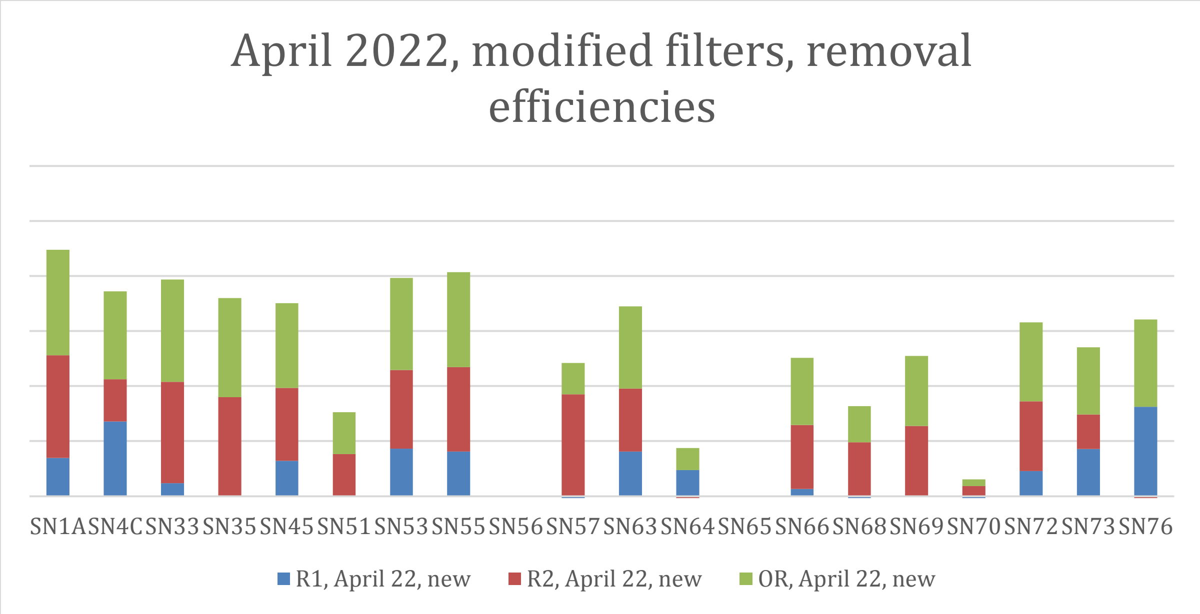


Figure 3. Removal efficiencies of the old filters (April 21), and the modified filters (April 2021, July 2021, November 2021 and April 2022) using, among others, data from table 1. Negative values for lower sandbed for some of the filters were left out as the concentration of As was already very low (generally < 10 µg/l) after nailbed and therefore the performance of the lower sandbed was not crucial (new filters April 2021). Negative values for lower sandbed (new filters April 2022) due to aging of the sand.
R1 = Removal efficiency 1 in % after nailbed
R2 = Removal efficiency 2 in % after lower sandbed
OR = Overall removal efficiency in %

Table 1. Removal effiencies
2021 o, old: Old filters, commonly in use since several years (at least since 2015)
2021 n, new: New filters
Removal efficiency 1 (R1, after nailbed): 100 - $(As_1*100)/As_2$
Removal efficiency 2 (R2, after lower sandbed): 100 - $(As_2*100)/As_3$
Overall removal efficiency (OR): 100 - $(As_1*100)/As_3$
As_1 = As concentration in groundwater, As_2 = As concentration after nailbed, As_3 = As concentration after complete filtration
As (µg/l) final: As concentration after complete filtration

April 2021

Tube-well	Fe (mg/l) 2021 o	As (µg/l) 2021 o	Res. time 2021 o	R1 2021 old	R2 2021 old	OR 2021 old	As (µg/l) final	Fe (mg/l) 2021 n	As (µg/l) 2021 n	Res. time 2021 n	R1 2021 new	R2 2021 new	OR 2021 new	As (µg/l) final
SN1A	4.27	95.5	10.98	31.8	78.5	85.3	14.0	4.27	95.5	5.17	98.8	-360	94.6	5.17
SN4C	2.58	105.4	4.65	29.1	47.6	62.9	39.1	2.58	105.4	31.01	51.4	93.4	96.8	3.41
SN33	1.75	401.8	16.96	8.4	50.6	54.8	181.8	1.75	401.8	7.75	97.8	67.2	99.3	2.91
SN35	1.18	295.0	18.09	10.0	60.7	64.6	104.3	1.18	295.0	5.81	98.9	8.25	99.0	3.05
SN45								0.18	2.0	6.5	71.0	-19.8	65.3	0.76
SN51	0.59	236.0	7.75	25.9	3.1	28.3	169.3	0.59	236.0	7.11	99.4	-173	98.2	4.17
SN53	0.51	211.6	23.26	32.5	-0.21	32.4	158.5	0.51	211.6	6.46	98.7	-49.6	98.1	4.47
SN55	0.55	198.2	16.15	8.3	37.3	42.5	114.0	0.55	198.2	6.46	98.4	-40.0	97.8	4.37
SN56	1.57	165.6	9.69	21.8	54.3	64.3	59.1	1.57	165.6	3.88	67.2	86.8	95.7	7.16
SN57	2.30	212.5	19.32	20.2	56.1	64.9	74.5	2.30	212.5	5.81	52.6	89.7	95.1	10.34
SN63	2.28	87.5	4.52	4.8	15.3	19.3	70.5	2.28	87.5	5.17	-12.44	91.1	90.0	8.73
SN64	1.04	122.4	29.07	-93.9	53.8	51.9	58.9	1.04	122.4	4.52	92.9	-125	91.4	10.5
SN65	2.44	255.4	12.27	12.4	64.2	68.7	80.0	2.44	255.4	6.46	97.9	-22.2	97.4	6.68
SN66	2.44	255.4	3.88	14.5	38.3	47.3	134.7	2.44	255.4	6.46	47.8	85.0	92.2	20.0
SN68	0.72	161.1	6.46	-1.32	27.2	26.3	118.8	0.72	161.1	5.17	98.1	-57.9	97.0	4.81
SN69	0.64	485.0	11.63	3	18.0	20.4	385.8	0.64	485.0	6.46	97.8	43.1	98.7	6.13
SN70	0.54	568.0	14.86	9.9	1.7	11.4	503.4	0.54	568.0	13.57	71.7	90.1	97.2	15.9
SN72	1.78	194.4	21.32	15.3	60.4	66.4	65.3	1.78	194.4	4.52	35.6	95.4	97.0	5.81
SN73	1.31	367.8	16.15	25.0	29.3	47.0	195.0	1.31	367.8	6.46	91.5	60.4	96.6	12.34
SN76	0.10	16.6	9.04	-10.7	-18.9	-31.7	21.8	0.10	16.6	5.81	98.7	-178.8	90.8	1.53

July 2021

Tube-well	Fe (mg/l) 2021 n	As (µg/l) 2021 n	Res. time 2021 n	R1 2021 new	R2 2021 new	OR 2021 new	Final conc. As (µg/l) new
SN1A	4.42	92.3	8.4	72.6	71.1	92.1	7.32
SN4C	2.29	85.6	12.27	57.0	62.3	83.8	13.9
SN33	1.65	362.9	10.98	79.3	89.2	97.8	8.09
SN35	1.75	312.6	12.27	89.0	71.5	96.9	9.82
SN45	0.024	2.1	6.46	38.1	54.3	71.7	0.59
SN51	1.92	180.0	16.8	94.6	-1.8	94.5	9.95
SN53	1.03	212.2	16.8	60.8	91.8	96.8	6.85
SN55	1.92	284.2	10.34	80.8	77.1	95.6	12.5
SN56	1.76	150.8	3.88	51.3	26.1	64.0	54.3
SN57	1.61	191.1	10.98	83.6	32.6	88.9	21.1
SN63	2.37	101.2	8.4	48.2	57.5	78.0	22.3
SN64	2.70	151.5	10.34	29.4	66.3	76.2	36.1
SN65	4.50	135	7.75	52.0	86.0	93.3	9.05
SN66	3.3	253.2	10.34	81.7	46.2	90.2	24.9
SN68	0.99	172.3	8.4	87.2	31.8	91.2	15.1
SN69	3.50	343.1	8.4	17.4	89.5	91.4	29.7
SN70	0.20	514.0	7.75	57.2	64.0	84.6	79.2
SN72	2.10	193.1	14.86	78.2	57.3	90.7	18.0
SN73	1.54	301.0	8.4	73.2	38.8	83.6	49.4
SN76	0.40	17.1	13.57	42.9	73.9	85.1	2.56

November 2021

Tube-well	Fe (mg/l) 2021 n	As (µg/l) 2021 n	Res. time 2021 n	R1 2021 new	R2 2021 new	OR 2021 new	Final conc. As (µg/l) new
SN1A	5.85	80.5	6.46	86.5	83.8	97.8	1.76
SN4C	2.99	75.0	6.46	51.7	63.8	82.5	13.1
SN33	0.90	261.8	8.70	62.2	79.9	91.3	22.9
SN35	1.60	297.1	9.04	72.7	82.9	95.3	22.9
SN45	<0.008	13.7	9.04	27.3	95.1	96.5	0.48
SN51	0.13	93.3	9.69	29.7	58.0	70.5	27.6
SN53	0.13	55.7	7.82	40.4	76.9	86.2	15.4
SN55	2.67	437.9	14.86	84.5	35.9	90.0	43.6
SN56	0.94	150.3	14.21	43.1	45.4	69.9	46.7
SN57	2.48	155.0	9.04	81.3	14.4	84.1	24.4
SN63	1.79	71.9	7.75	46.7	65.5	81.6	13.2
SN64	0.13	51.2	8.4	16.4	5.5	21.0	40.5
SN65	3.42	217.1	7.11	92.6	83.9	98.8	2.58
SN66	3.42	217.1	9.04	69.9	39.9	81.3	40.6
SN68	1.09	170.6	7.75	58.7	49.5	79.2	35.6
SN69	2.42	296.3	12.27	78.3	33.6	86.0	41.5
SN70	0.69	506.8	7.75	48.9	21.8	60.0	203.3
SN72	2.40	181.9	7.17	22.7	63.4	71.7	28.0
SN73	<0.008	221.2	9.69	61.8	-18.1	54.9	99.7
SN76	1.27	116.1	6.46	89.2	77.7	97.6	2.81

April 2022

Tube-well	Fe (mg/l) 2022 n	As (µg/l) 2021 n	Res. time 2022 n	R1 2022 n	R2 2022 n	OR 2022 n	Final conc. As (µg/l) n	Res. time 2022 new sand	R1 2022 new sand	R2 2022 new sand	OR 2022 new sand	Final conc. As (µg/l) new sand
SN1A	3.93	88.7	7.62	34.7	93.4	95.7	3.78					
SN4C	0.27	79.2	8.33	67.9	38.2	80.1	15.8					
SN33	1.32	366.1	6.85	11.8	92.1	93.0	25.5					
SN35	0.99	267.2	7.75	0.0	90.0	90.0	26.7					
SN45	0.02	2.0	7.36	32.2	66.1	77.0	0.53					
SN51	0.07	89.5	15.89	0.0	38.1	38.1	54.8					
SN53	0.70	201.5	12.48	43.2	71.4	83.8	32.7					
SN55	0.75	200.7	8.66	40.4	76.9	86.2	27.7	7.36	10.0	-2.5	8.2	184.2
SN56	not in use											
SN57	0.05	18.2	11.17	-843.3	92.5	28.6	13.0					
SN63	2.55	101.8	11.95	40.4	57.4	74.6	25.9					
SN64	1.72	99.1	7.95	23.6	-4.7	20.0	79.2	7.11	50.2	86.7	93.4	6.58
SN65	not in use											
SN66	1.55	214.8	7.75	6.7	58.0	60.9	84.1	8.01	28.9	95.4	96.7	7.07
SN68	0.35	77.5	19.19	-31.7	49.0	32.8	52.1	8.20	-94.1	94.8	89.9	7.82
SN69	0.35	283.4	8.91	0.30	63.5	63.6	103.1	6.85	-3.1	94.8	94.7	15.1
SN70	0.018	408.2	9.56	-3.6	9.3	6.0	383.5	5.49	14.5	92.4	93.5	26.5
SN72	0.77	99.0	7.17	22.7	63.4	71.7	28.0	7.82	80.8	58.6	92.1	7.87
SN73	1.32	390.9	8.14	42.9	31.4	60.8	153.3	6.78	36.0	95.4	97.1	11.5
SN76	0.27	15.9	10.66	81.3	-10.7	79.3	3.29					