Summary of Water Quality Assessment Findings
Greywater Sampling Report 1
Auja and Marj al Ghazal
Sample Date: 2019-09-23
Written By: Natalie Brassill

On September 23, 2019 a team of scientists from the Arava Institute traveled to the West Bank to Auja and Marj al Ghazal to assess Grey Water Treatment Systems that have been installed on site at homes in the area to treat household greywater using a similar design to the Septic Tank Up Flow Gravel Treatment unit as shown below in Figure 2.1. (Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues, Monther Hind design)

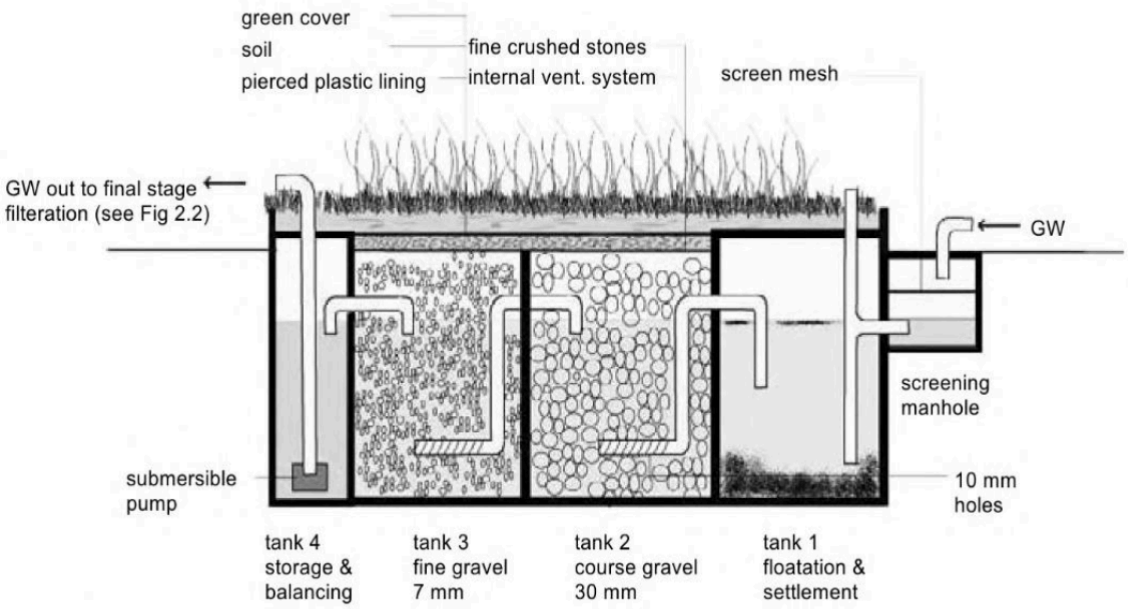

Figure 2.1 Septic tank up-flow gravel filter treatment unit

Following this treatment, the water is pumped into an empty tank at the top of a tower where the water then trickles through a second tank, part way full of charcoal and then trickles into a third tank where the water is stored over time for future use. This is an example of the possible final stage treatment in Figure 2.2 below. (Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues, Monther Hind design)

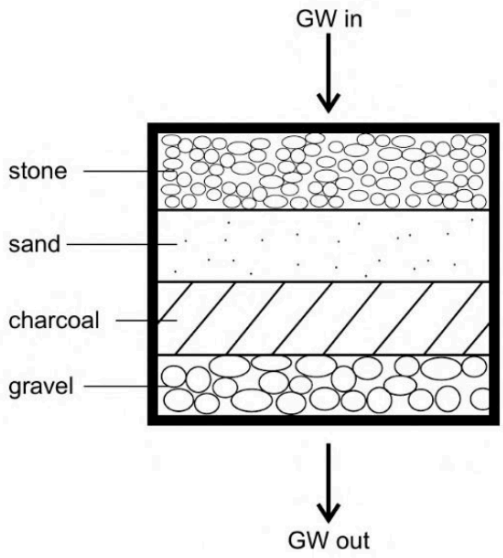

Figure 2.2 Final stage greywater filtration

These images were taken from Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues and do not exactly reflect the systems sampled but give a good picture of the general design.

Photo 1 below was taken from the first homeowner, Khalid's Farm, and shows the tower in which the greywater is pumped to post Septic Tank Up Flow Gravel Treatment. The Septic Tank Up Flow Gravel Treatment is an anerobic treatment without oxygen and the tower is an aerobic treatment with oxygen and with charcoal.

This is the design of the three systems that were sampled in the West Bank on September 23, 2019 by Natalie Brassill (University of Arizona, Water Microbiologist), Davis Blasini (Arizona State University, Plant Physiologist), Tom Groenveld (Ben Gurion University, Biogeochemist) Clive Lipchin (Arava Institute, Center for Transboundary Water Management) and Younes Issa Rjoub (Tel Aviv University, GIS Expert). This team of scientists visited 3 different locations to collect water samples of influent and effluent greywater. Influent comes from homes located near the Septic Tank Up Flow Gravel Treatment and is greywater from either a single household or multiple houses holds. Effluent is post treatment from Septic Tank Up Flow Gravel unit and aerobic charcoal tower unit.

Farm Sample Sites:

1. Kalid's Farm
2. Jihad Farm
3. Abuljarar Farm

Photo 1. Anerobic gravel treatment below ground and aerobic with charcoal above.

Greywater Sampling Material and Methods

Influent and Effluent samples were taken from each of the three Farm Sample Sites. There were 6 samples collected in total.

One 120mL water sample was collected to assess the fecal indicator organism *E. coli* quantitively using the Compartment Bag Test (Aquagenex, 2019). A 1:1, 1:10 and 1:100 dilution was performed on each sample to be able to attempt to quantify the concentration of *E. coli* in the samples.

One 50mL water sample was taken to assess Turbidity in NTU. Turbidity was measured using a Lutron TU-2016 Turbidity Meter (Taiwan) with 15mL of water sample.

Both of these tests were performed 24 hours post sample collection back at the laboratory at the Center for Transboundary Water Management Laboratory by Natalie Brassill.

At each site pH, Dissolved Oxygen (DO), Electrical Conductivity (EC), water temperature and air temperature were measured. Both the Influent and Effluent were assessed. A HACH meter HQ30d was used with appropriate probes for each measurement (HACH Company, Loveland Colorado, USA). DO was measured in mg/L and %. EC was measured in ppm and uS/cm. Water and air temperature was measured in Degrees Celsius. pH has no unit and is a measure of acidity and alkalinity.

One additional sample of groundwater was taken at Khalid's Farm and assessed only for EC.

Sampling Notes

Khalid's Farm system has been operating the longest, for about 1 year if not more. He cleaned his system 2 days prior to our sampling date. He has a farm that has ducks, geese, goats, cats and dogs. He makes goat cheese and grows date palm trees and uses this greywater to water his date palms and also his green house. All watering takes place using drip irrigation. He has cucumbers and tomatoes in his green house. See Khalid's system in Photo 1 above.

Jihad's Farm is in the city. He is using his greywater to water date palms through drip irrigation. There were not many animals around when we sampled, and Jihad has a beautiful garden porch. His date palms that are being irrigated are behind a wall by themselves. It seemed like he had just turned on his system when we arrived but that is not certain at this time of reporting. He was using the system correctly with both the Septic Tank Up Flow Gravel Treatment and aerobic charcoal tower (see Photo 1) but there was no water tricking through the aerobic tanks at that time. Water was sampled from his influent septic tank and effluent holding tank. Limited photos taken due to sampling conditions prohibiting touching of phones.

Photo 2. Jihad's Farm with influent manhole open for sampling

Photo 3. Jihad effluent holding tank that was sampled post treatment

Abuljarar Farm has many systems on site. Many have yet to be hooked up to irrigation of crops. When we arrived, we were brought to the first Septic Tank Up Flow Gravel Treatment System and it was off. They turned it on briefly but the water that would be treated was not connected to any irrigation drip line. We did not sample here due to the fact that it was not functioning as designed. The second system that we were shown was irrigating a lemon tree. This system was functioning but only the anaerobic aspect of the system was being used. The Septic Tank Up Flow Gravel Treatment was being used but the aerobic charcoal tower was being diverted. Abuljarar Farm was using the submersed pump from the treated water post Septic Tank Up Flow Gravel Treatment System to pump the water to the top of the tower but were then using gravity flow to move the water from the top tower tank to irrigate a lemon tree downhill. The charcoal treatment was diverted completely in this use. Limited photos taken due to sampling conditions prohibiting touching of phones.

Photo 4. Abuljarar Farm with system yet to be installed on left side of photo

Results

Table 1. Greywater parameters assessed

Site Location	System Use Style; Use system as Normal (tower included) or list modification	Water Type	Date	Time	Air Temp Degrees C	Water Temp Degrees C	pH	EC ppm	EC uS/cm	Dissolved Oxygen (DO) mg/L	Dissolved Oxygen (DO) % saturation	Turbidity NTU Digital Meter @Arava	FECAL INDICATOR generic *E. coli* 1:1 MPN/100mL	FECAL INDICATOR generic *E. coli* 1:10 MPN/100mL	FECAL INDICATOR generic *E. coli* 1:100 MPN/100mL
Khalid Farm	influent	Influent	2019-09-23	12:00	42.8	34.5	6.10	350	893	0.68	9.5	1198	>100	>1000	>10,000
Khalid Farm	Normal	Effluent	2019-09-23	12:00	35.0	33.9	8.17	ND	858	4.05	55.5	35.67	>100	>1000	1500
Khalid Farm	ground water	ground water	2019-09-23	12:30	NA	NA	NA	3.21	6320	NA	NA	NA	NA	NA	NA
Jihad Farm	influent	Influent	2019-09-23	13:40	33.7	30.8	6.76	241	560	0.13	1.7	764	>100	>1000	>10,000
Jihad Farm	Normal	Effluent	2019-09-23	13:27	37.1	34.3	7.02	159.1	396	5.66	80.6	20.75	>100	>1000	>10,000
Abuljarar Farm	influent	Influent	2019-09-23	16:10	31.0	29.0	7.38	388	900	0.68	8.5	243	1.5	0	0
Abuljarar Farm	No Charcoal	Effluent	2019-09-23	16:00	32.4	32.3	7.06	148.5	362	6.41	6.86	58	0	0	0

Conclusions

All systems regardless of use improved water quality generally. EC was reduced, DO was increased, Turbidity was reduced, and pH had little change but stayed around neutral from 6-8. This is all very good!

However, when it comes to fecal indicator bacteria *E. coli* Khalid's Farm was the only one that showed a reduction of about one order of magnitude (1 log) from >10,000 MPN/100mL to 1500 MPN/100mL. The standard in the USA Food and Drug Administration (FDA) for irrigation water is < 126 MPN/100mL. This is water that would be used for irrigation where the water would touch the edible portion of the crop. Khalid's Farm is not meeting the USA standard for irrigation water use for touching edible crops but he is also using drip irrigation that is being targeted to the root zone of the plant for cucumbers and tomatoes and he is irrigating date palms that have no restrictions because the edible date will never touch the irrigation water because it is a tree crop. Technically if he is in compliance with USA FDA. But the system itself was successful in reducing bacteria so that is great!! The other Farms not the same results. There was no reduction in *E. coli* bacteria at Jihad's Farm. The influent was >10,000 MPN/100mL and the effluent was also >10,000 MPN/100mL. At Abuljarar Farm there was only 1.5 MPN/100mL of *E. coli* in the influent and it was reduced to 0 MPN/100mL in the effluent but since there was no *E. coli* initially it infers that this system was not being utilized by multiple households and may have been underactive.

Overall the Septic Tank Up Flow Gravel Treatment has a positive effect on water quality.

Photo Album

Photo 5. Khalid removing irrigation line from effulent take for sampling

Photo 6. Collecting turbidity sample from Khalid effluent tank (Clive & Natalie)

Photo 8. Tom data recording and Natalie taking DO meaure at Khalid Farm

Photo 9. Collecting EC sample of ground water at Khalid's Farm

Photo 10. Davis and Tom taking HACH readings at Abuljarar Farm

Photo 11. Compartment Bag Test (CBT) set up for dilutions and *E. coli* quantification at Lab

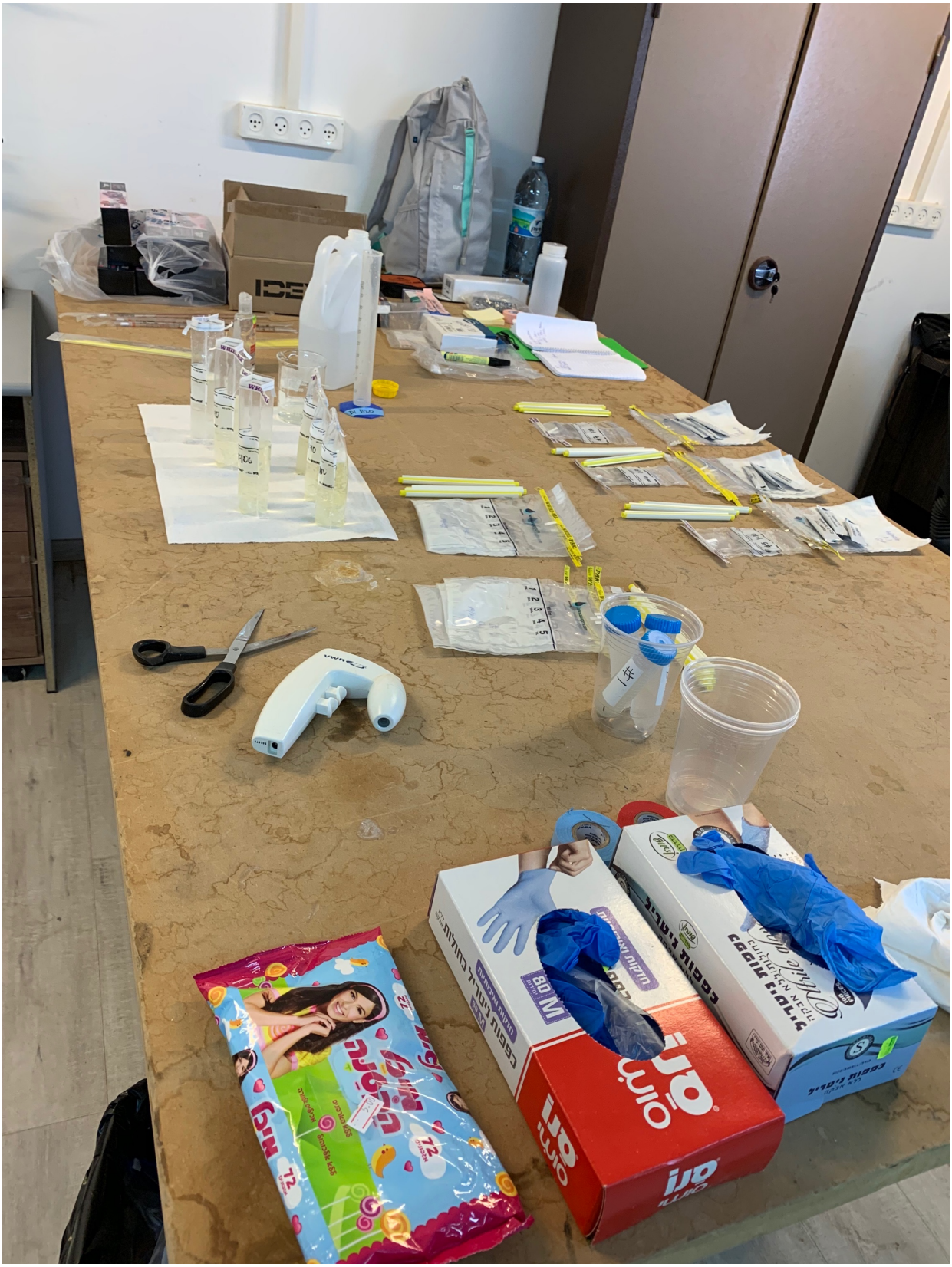

Photo 12. Lab work bench with CBT samples being diluted and turbidity samples waiting for test

Photo 13. 1:1, 1:10 and 1:100 CBT dilution bench top set up before sample added to CBT bag

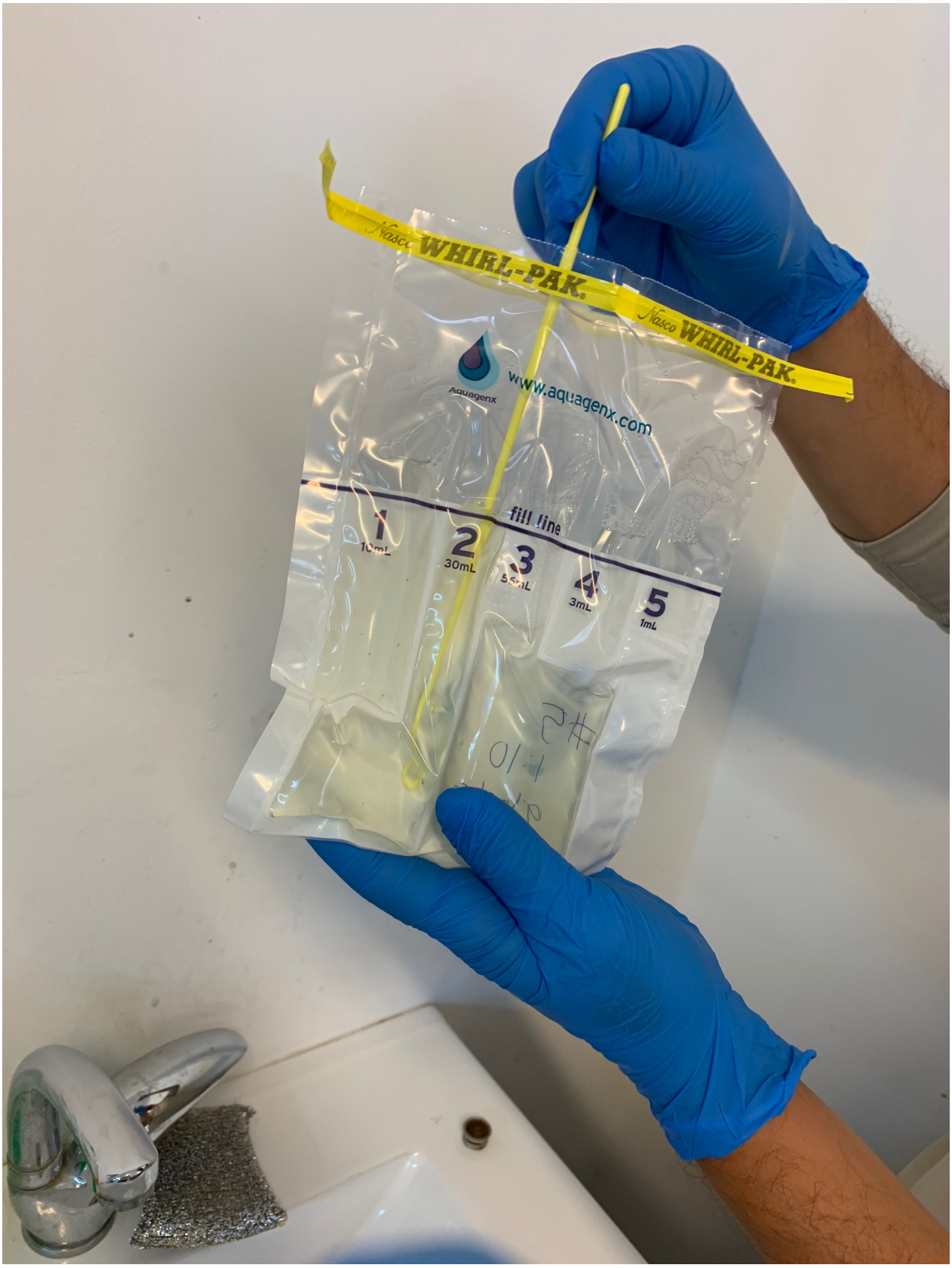

Photo 14. Filling of CBT test bag with sample prior to incubation

Photo 15. CBT bag ready for incubation at about 37C for 24 hours.

Photo 16. Outdoor incubation at ambient temperature (26C-37C) for 24-36 hours.

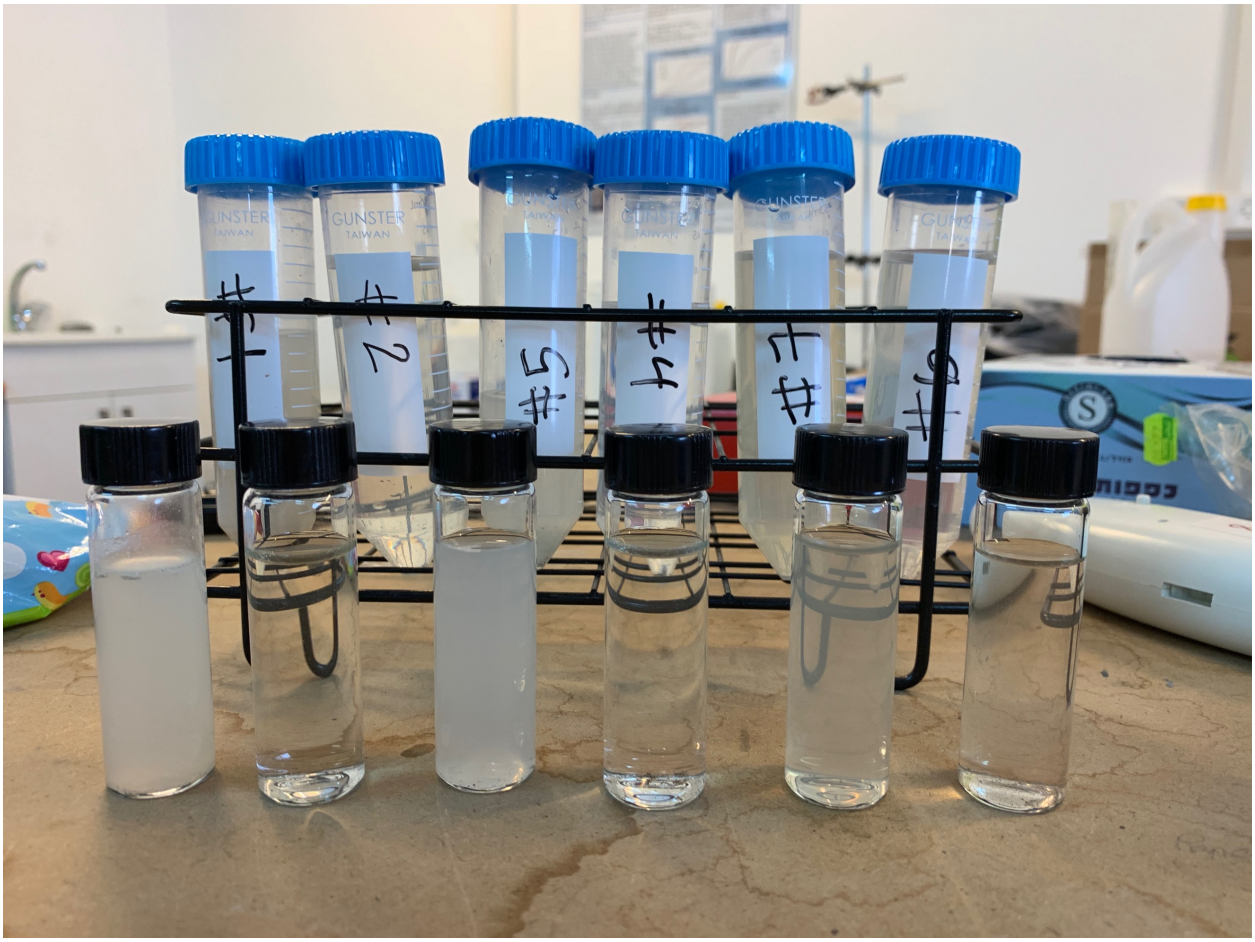

Photo 17. Influent and Effluent samples being assessed for turbidity. Notice how much more clear the effluent is vs the influent from each sample site. 1&2 Khalid, 5&4 Jihad, 7&6 Abuljarar

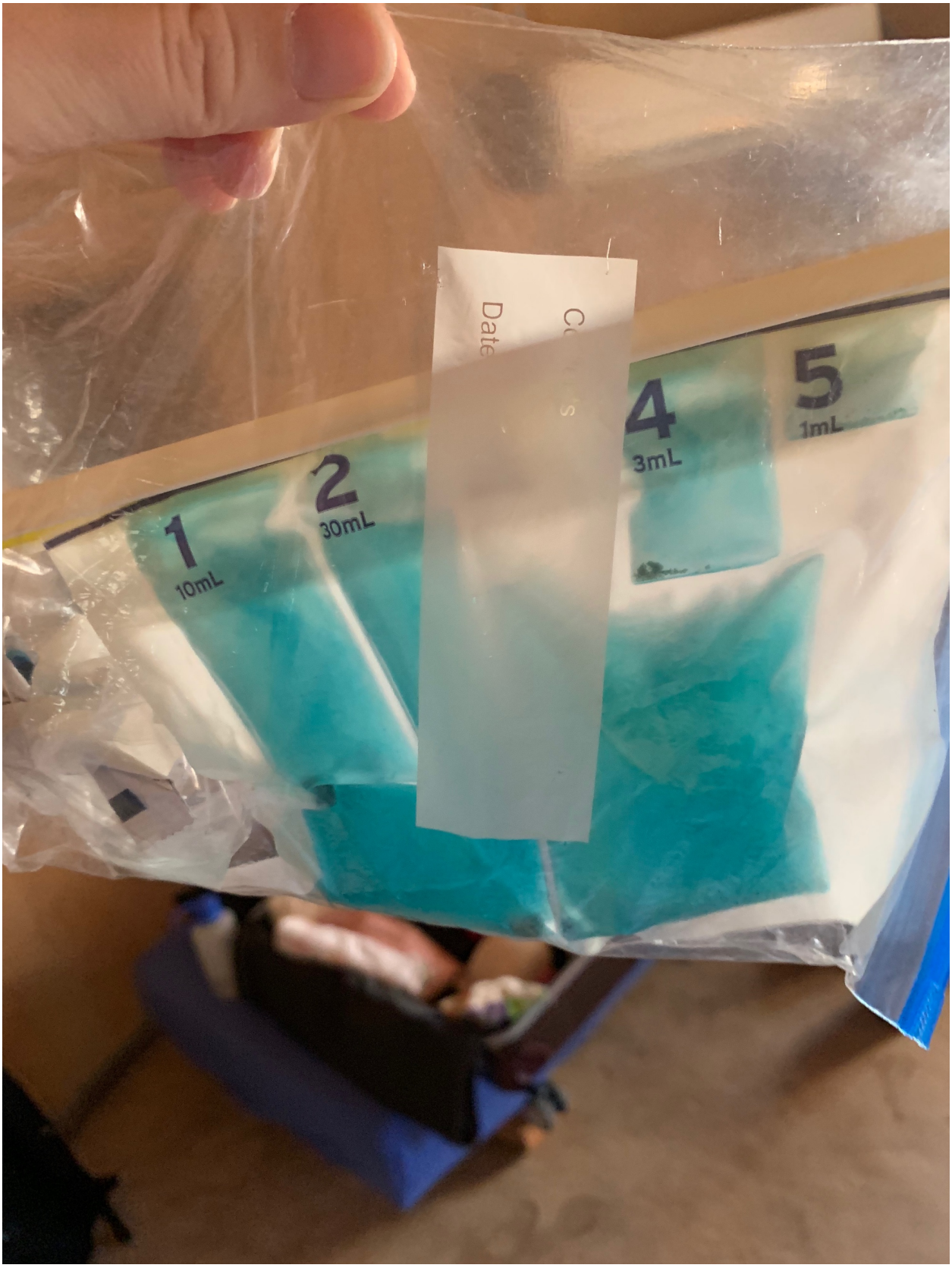

Photo 18. CBT post incubation where blue indicates *E. coli* presence.