Summary of Water Quality Assessment Findings
Greywater Sampling Report 3
Auja and Marj al Ghazal
Sample Date: 2019-10-24
Written By: Natalie Brassill

On October 24, 2019 a team of scientists from the Arava Institute traveled to the West Bank to Auja and Marj al Ghazal, for the third time, 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) This design was modified by Monther Hind to fit the needs of each on site location.

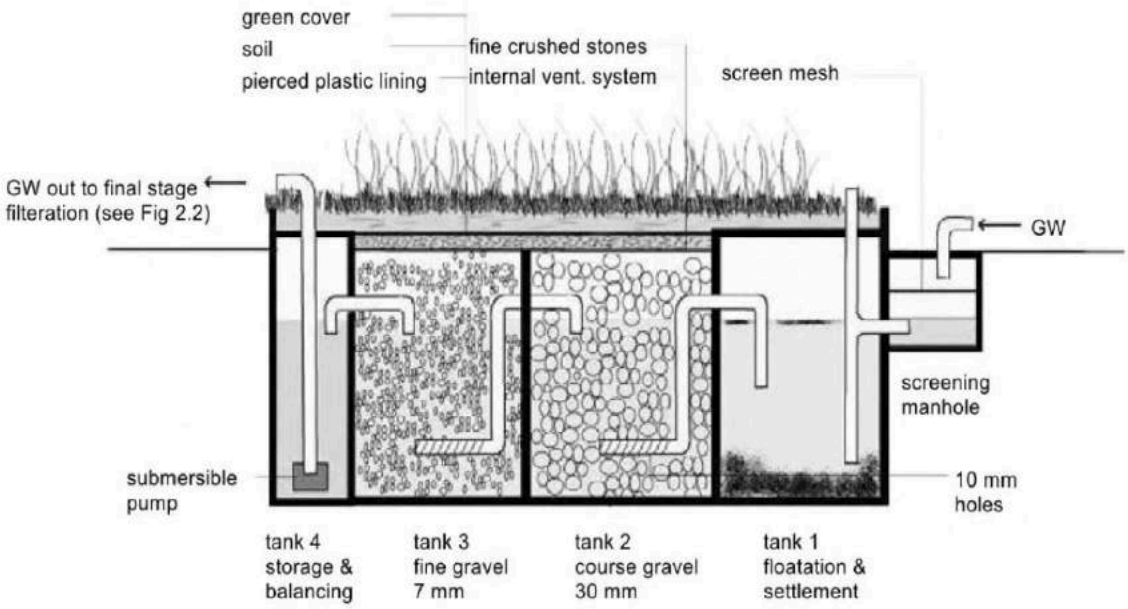

Figure 2.1 Septic tank up-flow gravel filter treatment unit

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)

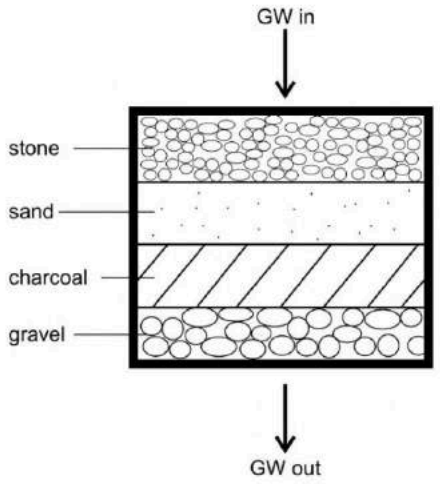

Figure 2.2 Final stage greywater filtration

These images were taken from Greywater Use in the Middle East: Technical, Social, Economic and Policy Issues, 2010 and do not exactly reflect the systems sampled but give a good picture of the general design. After discussing these designs with Monther Hind it was conveyed that the systems installed in Al Auja and Marj Al Ghazal, that are currently in place in 2019, were modified upon installation to fit the needs of the land and area as installation was performed.

This schematic below, Figure 1 was shared on 03-11-2019. This is the current installation at the farms in the West Bank. This Off Grid Greywater Treatment Unit GWTU scheme is composed of an initial settling tank (a), two anaerobic gravel-based filter tanks (b), a charcoal filter (c), and a reservoir to store water until used for irrigation (d). See below. In this scheme you can see similarities to Figure 2.1 above. The water in Figure 1 is moving left to right as it is becoming more treated. The charcoal aeration tower is shown in Figure 1 and is a similar design to Figure 2.2 but here you can see the 3 stages and the tower design. This is the final step in the GWTU.

Figure 1. GWTU, Monther Hind Installation West Bank

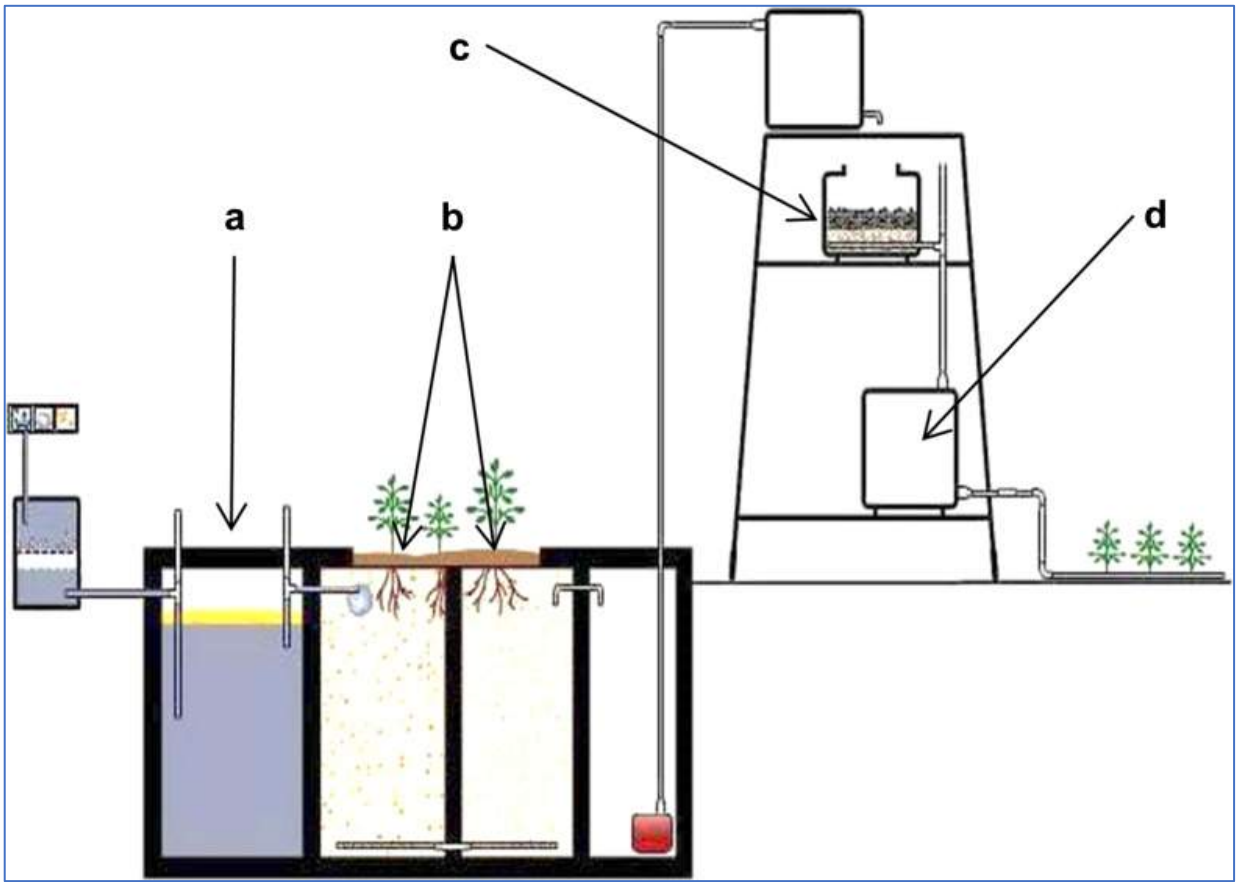

Photo 1 below was taken from the first homeowner, Khalid's Farm, and shows the tower in which the greywater is pumped to post Septic Tank Up Flow Gravel Treatment. The Septic Tank Up Flow Gravel Treatment is an anerobic treatment without oxygen and the tower is an aerobic treatment with oxygen and with charcoal. This is the design of the three systems that were sampled in the West Bank on October 24, 2019 by Natalie Brassill (University of Arizona, Water Microbiologist), Davis Blasini (Arizona State University, Plant Physiologist) and Tom Groenveld (Ben Gurion University, Biogeochemist). This team of scientists visited 5 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. Greywater is sink and shower wash water that does not contain feces. Blackwater is toilet water and is sent to a septic tank and kept separate. Effluent is post treatment greywater from the Septic Tank Up Flow Gravel unit and aerobic charcoal tower unit. It is considered effluent after it goes through the Septic Tank Up Flow Gravel unit below ground and still effluent after it gets the additional treatment of charcoal and aeration.

Farm Sample Sites on 2019-10-24:

1. Kalid's Farm (Al Auja)
2. Jihad's Home (Al Auja)
3. Marj al Ghazal 1
4. Marj al Ghazal 2
5. Marj al Ghazal 3

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

Household Greywater Sampling Material and Methods

Influent and Effluent samples were taken from each of the 5 Farm Sample Sites. At Khalid's Farm we evaluated his in-home drinking water and took and extra effluent sample. There were 12 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 within 30 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.

The additional sample of potable water that was taken at Khalid's Farm from his in-home tap (that he does not drink) was assessed for *E. coli* and Total Coliform bacteria, turbidity and all other physical parameters.

Sampling Notes

Khalid's Farm system has been operating the longest, for about 1 year if not more. This is the third time that the team had sampled from Khalid's Farm Household Grey Water Up Flow Gravel Treatment System. This time samples were taken from the influent tank (same as previous) and from the effluent tank below ground before it is pumped out of the underground effluent tank to the charcoal aeration tower to see if there is a difference in treatment. This sample can be compared to samples taken on 06-10-2019. A second effluent sample was also taken from the final effluent storage tank. This sample can be compared to samples taken on 23-09-2019. The first sampling event, 23-09-2019, the effluent was taken from the final storage tank post aerobic tower with charcoal. It was thought that bacteria could be harboring in the final storage tank below the spigot causing possible cross contamination. A sample was taken post underground anerobic treatment only to see if there was a difference in the samples. The results are such a small set they cannot be compared directly and with so many days in between sampling events comparing charcoal vs no charcoal not on the same day is not relevant.

Figure 3. Khalid's results over the three sampling events here:

Site Name	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	influent	Influent	2019-10-06	10:31	35.8	32.3	5.84	350	861	0.28	3.9	1443	>100	>1000	>10,000
Khalid Farm	No Charcoal	Effluent	2019-10-06	10:05	33.5	30.6	7.39	388	889	1.26	16.7	21.19	>100	>1000	4830
Khalid Farm	influent	Influent	2019-10-24	9:34	26.0	28.5	6.28	316	696	1.08	13.6	1680	>100	>1000	>10,000
Khalid Farm	No charcoal	Effluent	2019-10-24	9:01	24.0	28.3	7.95	398	866	0.79	9.8	29.48	>100	>1000	>10,000
Khalid Farm	normal	Effluent	2019-10-24	9:25	26.0	28.5	7.84	392	857	3.85	ND	27.73	>100	>1000	>10,000

Khalid has a farm that has ducks, geese, goats, cats and dogs. In this last event we did not see a reduction in *E. coli* bacteria in his system like we saw in the first two events as seen above in Figure 3. He has not cleaned the system since 2019-09-21.

Khalid makes goat cheese, harvests honey, grows bananas, a few lemon trees, a few grape trees and many date palms trees. He uses this greywater to water his date palms and also his green house. All watering takes place using drip irrigation. He has grown cherry and table tomatoes and paprika in his green house. He is moving his greenhouse to accommodate a water desalination system for agricultural water that he is installing in December 2019 and will not be growing tomatoes until January 2020. Khalid gets his agricultural water from a well on his property that he shares with some surrounding farmers. Khalid is happy to have the Household Greywater Treatment System (GWTS) on his property because this allows him to not have to pump is septic system as often. Before the GWTS was installed Khalid would have to pump his septic system once every 2 months because he would have both grey and black water in the septic tank, and it would get filled to capacity quickly. Now that he has the GWTS and the greywater in now diverted to the treatment system and the water is used to irrigate trees he has less water going into his septic tank and now needs to have it pumped once every two years. The amount of treated greywater that is produced is only enough to water about 10 date palm trees according to Khalid and he says that this is about 10% of his total irrigation water portfolio. In 2018 Khalid grew paprika in his greenhouse with the treated greywater and made 700 NIS in profit. He also grew ½ ton of table tomatoes and make 3000 NIS in profit that same year. He tried to grow cherry tomatoes, but it was not successful, and he thinks this maybe related to the water quality for growing. Overall Khalid is happy to pump his septic less and have some additional water that is not so saline near his greenhouse. I did discuss with Khalid in detail how the water has very high levels of *E. coli* bacteria and is not good for public health if you do not use subsurface drip irrigation. He understands this and aware of cross contamination. He practices handwashing and does not let his crops touch the treated greywater.

Photo 2. Khalid's Yard October 24, 2019

Photo 3. Khalid and his system aerobic charcoal tower on October 6, 2019

Photo 4. Khalid Up Flow Gravel Greywater Treatment System October 6, 2019

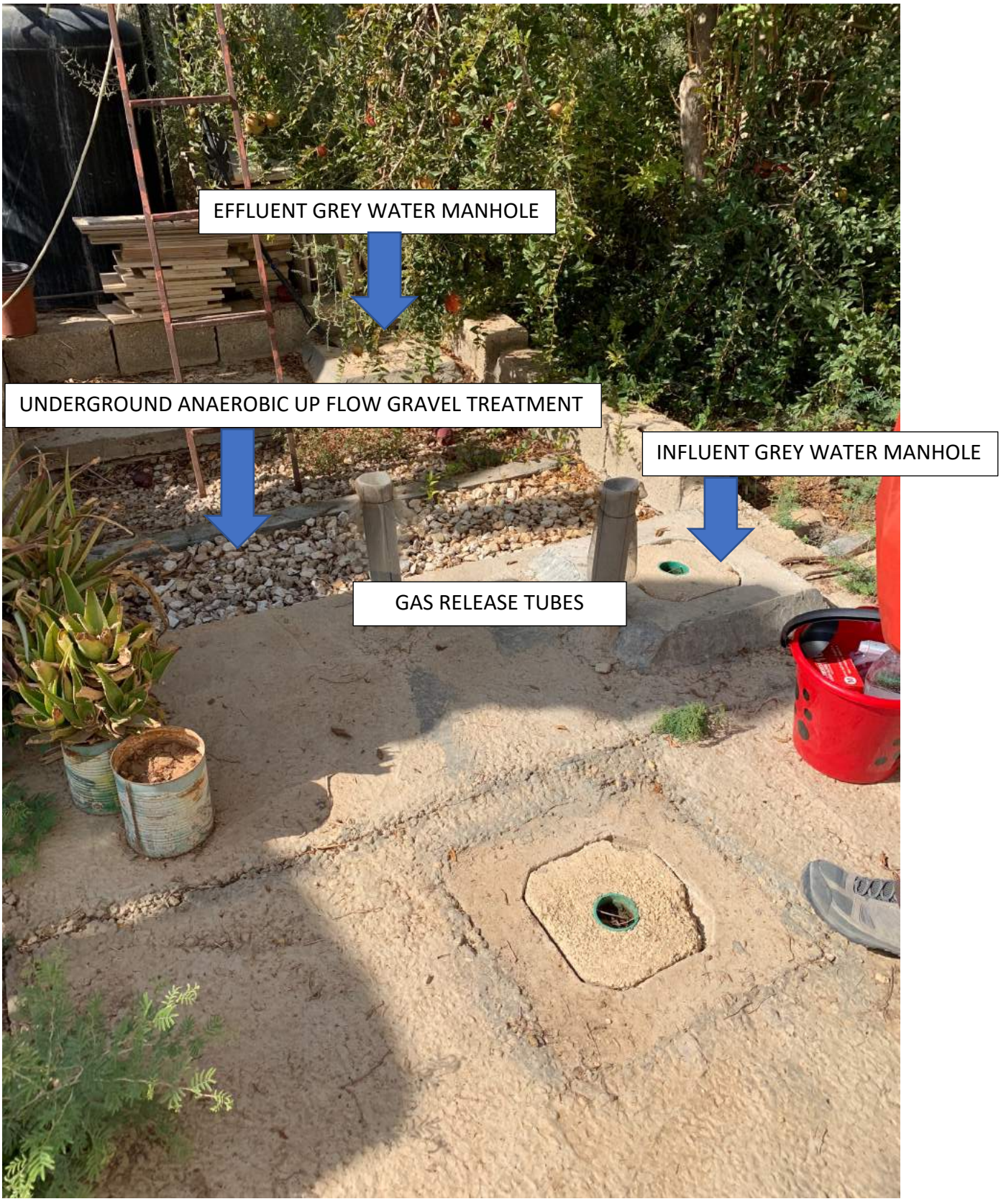

Photo 5. Sampling Khalid's Influent Tank with visible scum October 24, 2019

Photo 6. Natalie with Influent Samples before taking them to be stored in the cooler

Khalid requested that we take a sample of the water that comes out of his sink. This is the water that he uses for washing dishes and showering and it bought from the municipality and travels through pipelines to his home. This is potable water, but he does not drink it. This is the water that would be coming into his greywater system after it is used for household activities. The water that he drinks is either mineral water that he buys in a bottle from the store or water from the Sultan Spring that he collects using reusable containers. He does not drink the municipal water that he buys that comes through his tap and wanted us to test it to see if there were bacteria present. We found that there were zero *E. coli* bacteria but there were some Total Coliforms in this water. This shows that there may be soil or sediment present in the lines. See the results section for more detail.

The next place that we visited on October 24, 2019 was Jihad's home also in Al Auja but a much more urban location versus Khalid's. Jihad lives next to a school in Al Auja and has a GWTS for his home greywater and this treated greywater water's 2 palm trees next to his home that are surrounded by a fence. We also sampled here on 2019-09-23.

Photo 7. The top of Jihad's GWTS gravel upflow tanks with beautiful green cover growing

Photo 8. Jihad's Household Greywater Treatment System on October 24, 2019

Photo 9. Tom sampling Dissolved Oxygen at Jihad's in Al Auja, sample taken from storage tank

Photo 10. Date Palms being watered at Jihad's home

Marj Al Ghazal (town), or Abuljarar Farm as it was called in Report 1, has many systems on site. During this visit on October 24, 2019 three systems were sampled from. This was the second sampling event for all three. The first site that we went to I believe to be the home of Mohamed Abo Jarar Abo Jamal. This system is in the second entrance to Marj Al Ghazal and I have named in my raw data "many houses, second entrance". This system seems to be hooked up and being used by these homes. The treated grey water is stored in the holding tank and released on nearby date palms. In the last report from October 6, 2019 we sampled the influent and the final holding tank. This time on October 24, 2019 there was no water in the holding tank, so we sampled the influent and the effluent underground.

The second location that we visited in Marj Al Ghazal in October 24, 2019 was a system that is more in the center of the community and we believed was hooked up to 3-4 homes and was irrigating 10 date palms. In Report 2, I reported that the Influent from this location was very clear indicating visually that the water was not heavily used by kitchen cooking or showering. The results that I saw from the *E. coli* assessment indicated that the system was not being used much with only 2.6 *E. coli* bacteria in the influent and zero *E. coli* measured in the effluent. This time when we visited Tom looked around the property further and found that the homes were not even piped to the GWTS. This explains why the influent water seemed so clean. After sampling and taking most of our readings is when it was discovered that there were not even pipes from the homes entering the split tank where the grey water is pumped to the GWTS and the blackwater is diverted. Last report we spoke to a member of the community who went on and on about how this system when it overflows, they bring a tractor to divert the water to palm trees and how they manage the system. He must have been speaking generally because this system is not even in operation. This was a perfect example of miscommunication between the translator and the client and also how the translator himself does not even know which systems are hooked up or not or how he does not truly hear the questions the scientists are asking. The samples collected were not processed from this site in the lab because there is no point in processing from a system that is not functioning. There was water in the system possibly for leak detection but not from use as no pipes go to it at this time.

The third system that was visited in Marj al Ghazal in October 24, 2019 we also sampled on September 23, 2019 and at that time was watering a lemon tree so in that raw data sheet that is what is noted in the GPS section. This system, as reported in Report 1, when sampled on September 23, 2019 was using the gravity of the charcoal tower to feed the irrigation to the lemon tree. On that date the influent was sampled and the effluent at the tree was sampled. On October 24, 2019 on the second sampling event the influent was sampled again but this time the system was not irrigating any trees. The effluent was sampled from underground because the holding tank was emptied. On both occasions the influent was sampled and the effluent without the use of the charcoal filter was sampled. Based on the results of the influent during this sample event I think that this system may not be hooked up to homes as well. The influent had little *E. coli* numbers and the effluent had high numbers. We assessed the area and it seemed like this system was not directly hooked up to homes at the time but the whole area had been covered in a thick layer of dirt and it was hard to follow any pipelines. Communication about system use is critical to project purpose, effectiveness and longevity of research.

Photo 11. System 1 at Marj Al Ghazal at Mohamed's 4-5 homes. Seems to be working but not hooked up to irrigation at time of sampling as seen in photo

Photo 12. System 2 at Marj Al Ghazal that was found to have no pipes coming in from homes. Did not find out until samples taken and parameters measured upon investigation of area.

Photo 13. Marj Al Ghazal 2 tank from 2019-10-06 trip when assumed was working—not plumbed and no homes contributing water 2019-10-24

Photo 14. Davis sampling influent manhole at Marj Al Ghazal 3 “lemon tree”

Photo 15. Tom preparing palm to be used as device to collect effluent water from deep tank

Photo 16. Tom collecting effluent sample. See debris around indicating construction

Photo 17. Another angle of Marj Al Ghazal 3 “lemon tree” dirt cover and cement blocks

Photo 18. Natalie and Tom investigating household greywater water quality

Results

Table 1. Treated Greywater Quality Parameters Assessed Section 1

Site Name	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
Al Auja Khalid	influent	Influent	2019-10-24	9:34	26.0	28.5	6.28	316	696
Al Auja Khalid	no charcoal	Effluent	2019-10-24	9:01	24.0	28.3	7.95	398	866
Al Auja Khalid	normal	Effluent	2019-10-24	9:25	26.0	28.5	7.84	392	857
Al Auja Khalid	home potable water	home potable water	2019-10-24	10:00	31.4	31.2	8.49	94.1	224
Al Auja Jihad	influent	Influent	2019-10-24	11:00	27.0	29.0	6.95	280	624
Al Auja Jihad	Normal	Effluent	2019-10-24	11:00	27.0	31.0	7.96	303	701
Marj al Ghazal 1	influent	Influent	2019-10-24	12:20	29.0	28.7	6.28	300	676
Marj al Ghazal 1	No Charcoal	Effluent	2019-10-24	12:11	29.0	29.4	8.27	343	770
Marj al Ghazal 3	influent	Influent	2019-10-24	12:55	30.0	29.3	7.95	394	873
Marj al Ghazal 3	No Charcoal	Effluent	2019-10-24	12:51	30.0	28.6	9.04	287	636

Table 2. Treated Greywater Quality Parameters Assessed Section 2

Site Name	System Use Style; Use system as Normal (tower included) or list modification	Water Type	Date	Dissolved Oxygen (DO) mg/L	Dissolved Oxygen (DO) % saturation	Turbidity NTU Digital Meter @Arava
Al Auja Khalid	influent	Influent	2019-10-24	1.08	13.6	1680
Al Auja Khalid	no charcoal	Effluent	2019-10-24	0.79	9.8	29.48
Al Auja Khalid	normal	Effluent	2019-10-24	3.85	ND	27.73
Al Auja Khalid	home potable water	home potable water	2019-10-24	8.17	106	3.82
Al Auja Jihad	influent	Influent	2019-10-24	0.10	1.3	620
Al Auja Jihad	Normal	Effluent	2019-10-24	0.11	1.5	37.85
Marj al Ghazal 1	influent	Influent	2019-10-24	0.69	8.7	442
Marj al Ghazal 1	No Charcoal	Effluent	2019-10-24	0.27	3.4	28.59
Marj al Ghazal 3	influent	Influent	2019-10-24	1.39	17.4	89
Marj al Ghazal 3	No Charcoal	Effluent	2019-10-24	6.25	78.1	23.26

Table 3. Treated Greywater Quality Parameters Assessed Section 3

Site Name	System Use Style; Use system as Normal (tower included) or list modification	Water Type	Date	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
Al Auja Khalid	influent	Influent	2019-10-24	>100	>1000	>10,000
Al Auja Khalid	no charcoal	Effluent	2019-10-24	>100	>1000	>10,000
Al Auja Khalid	normal	Effluent	2019-10-24	>100	>1000	>10,000
Al Auja Khalid	home potable water	home potable water	2019-10-24	0	0	0
Al Auja Jihad	influent	Influent	2019-10-24	>100	>1000	>10,000
Al Auja Jihad	Normal	Effluent	2019-10-24	>100	>1000	1360
Marj al Ghazal 1	influent	Influent	2019-10-24	>100	>1000	>10,000
Marj al Ghazal 1	No Charcoal	Effluent	2019-10-24	17.1	NA	0
Marj al Ghazal 3	influent	Influent	2019-10-24	13.6	0	0
Marj al Ghazal 3	No Charcoal	Effluent	2019-10-24	>100	>1000	1200

Table 4. Treated Greywater Quality Parameters Assessed Section 4

Site Name	System Use Style; Use system as Normal (tower included) or list modification	Water Type	Date	Total Coliforms 1:1 MPN/100mL	Total Coliforms 1:10 MPN/100mL	Total Coliforms 1:100 MPN/100mL
Al Auja Khalid	influent	Influent	2019-10-24	>100	>1000	>10,000
Al Auja Khalid	no charcoal	Effluent	2019-10-24	>100	>1000	>10,000
Al Auja Khalid	normal	Effluent	2019-10-24	>100	>1000	>10,000
Al Auja Khalid	home potable water	home potable water	2019-10-24	48.3	NA	NA
Al Auja Jihad	influent	Influent	2019-10-24	>100	>1000	>10,000
Al Auja Jihad	Normal	Effluent	2019-10-24	>100	>1000	>10,000
Marj al Ghazal 1	influent	Influent	2019-10-24	>100	>1000	>10,000
Marj al Ghazal 1	No Charcoal	Effluent	2019-10-24	>100	>1000	>10,000
Marj al Ghazal 3	influent	Influent	2019-10-24	>100	>1000	>10,000
Marj al Ghazal 3	No Charcoal	Effluent	2019-10-24	>100	>1000	>10,000

Conclusions

All systems have been treating the greywater and improving its quality generally. During this sampling event Khalid in Al Auja we sampled both his underground effluent and the final holding tank effluent. There was not a vast difference between the two other than Dissolved Oxygen increase which is indicating that the aerobic charcoal tower is allowing for aeration. Through treatment an increase in pH, an increase in EC an increase in DO and a decrease in turbidity was observed. These are general improvements in water quality. There was no change in *E. coli* bacteria observed this sample event indicating that the treatment effectiveness against indicator bacteria has reduced. When reviewing the Raw Data form or Report 1 & 2 it is

shown that *E. coli* treatment has gradually worsened since over time (9/23: 1500 MPN/100mL, 10/6: 4830 MPN/100mL, 10/24: >10,000 MPN/100mL). The system potentially needs to be cleaned again. It was last cleaned one month ago. The pH went from 6.28-7.95 becoming less acidic and more neutral which is good. EC is expected to be lower but during this assessment EC went up from 316 ppm to 398 ppm, but this is not a large increase. This was also observed in Report 2. DO increased from 1.08 to 3.85 when using the charcoal tower but actually decreased from 1.08 to 0.79 as measured from the underground effluent tank. The turbidity was significantly reduced from 1680 NTU to 27.73 NTU which is fantastic for drip irrigation to help limit clogging of lines. Positive results showing that the system is treating the water for turbidity. During this sample event Khalid's system did not reduce *E. coli* bacteria and it was found to be >10,000 MPN/100mL in the influent and effluent. This water is only safe to put on trees using subsurface drip at these bacteria readings. Overall at Khalid's Farm the household grey water is being treated and has reductions during this assessment. We also assessed his household municipal water that he receives through pipelines but does not drink. There were no *E. coli* bacteria found in the water but there was Total Coliforms found. This is a positive result to have no fecal indictor organisms but also shows that there could be dirt in the system or a leak of some kind. Total coliforms live in all soil. Drinking water should have zero bacteria period. Khalid's water did not have *E. coli* but did have Total coliforms, so it is good that he does not drink this water and just uses it for showers and boiling. It is similar to river water with these readings. The Total Coliform results show 48.3 MPN/100mL and that is low. This water should be evaluated more to draw accurate conclusions.

Al Auja Jihad saw an increase in pH, an increase in EC, no change in DO and a decrease in turbidity. There was a reduction in *E. coli* bacteria between the influent and effluent showing treatment effectiveness which is great. The *E. coli* bacteria reduced by 0.87 log. Not quite a whole 1 log reduction but still significant. The pH went from 6.95-7.96 and the EC increased from 280 ppm-303ppm, these are both not large changes and still indicate positive water quality. The Dissolved Oxygen (DO) did not change between influent (0.10 ppm) and effluent (0.11 ppm). This may indicate that the water in the holding tank had been sitting there for some time and had not been recently treated. The turbidity was significantly reduced from 620 NTU to 37.85 NTU also showing treatment effectiveness. The fecal indicator bacteria *E. coli* was reduced from >10,000 MPN/100mL to 1360 MPN/100mL. This is a positive result and a log reduction of 0.87 as previously stated. During Report 1 there was no log reduction seen at Jihad's system after sampling on 2019-09-23. It is good to see that a log reduction was measured on 2019-10-24. It would be helpful to ask Jihad if there was any change in his behavior with his greywater, changes in the kitchen, what has gone down the sink in the last month, number of household guests, etc. Jihad was not present this time to communicate with, but a follow up interview would be helpful when results like this are found. There was no change in Total Coliform bacteria as typically reported in these systems.

Marj Al Ghazal 1 (Mohammed's home) saw an increase in pH, an increase in EC, a decrease in DO and a decrease in turbidity and *E. coli* bacteria. This is similar to what was reported in Report 2 when this system was last evaluated. This system was labeled Marj Al Ghazal 2 in the last report because it was the second one sampled, but both are noted that this is Mohammed's home with 4-5 houses attached to the system supposedly. The pH increased from 6.28-8.27 and the EC increased from 300 ppm-343 ppm. In the last sample event, the influent was sampled the same, but the effluent was sampled from the holding tank (Report 2). In this sample event the effluent was sampled from underground. The DO during 2019-10-24 sample event decreased post treatment from 0.69 ppm-0.27 ppm. This is expected in an anaerobic system. The turbidity decreased from 442 NTU-28.59 NTU showing treatment effectiveness and the E. coli also reduced from >100 MPN/100mL to 17.1 MPN/100mL. This is a reduction of 0.77 log, almost a whole log reduction and an indication of a working system treating E. coli and turbidity to be reduced. These numbers are safe to be irrigating not only tree crops but also vegetables. In Report 2 however the fecal indicator organism, *E. coli* bacteria went from >10,000 cells per 100mL to 4830 cells per 100mL. This is a reduction of less than 1 log (~0.32 log). During this second sample event the *E. coli* reduction was found to be greater. This is an example of system variability and how monitoring over time is important. It would also be good to interview the homeowner to see if there were any changes in home practice like maybe there were more guests during the 2019-10-06 time period versus the 2019-10-24 time period.

Marj Al Ghazal 2 was not tested due to system not being plumbed to homes.

Marj Al Ghazal 3 was tested. This is the site at the "lemon tree". This site appeared to be under construction or tampered with and that is what results seemed to indicate. Marj Al Ghazal 3 was sampled both from the underground influent and effluent as there was no water in the holding tank or irrigating. An increase in pH was recorded from 7.95-9.04, a decrease in EC from 394 ppm-287 ppm, an increase in DO from 1.39 ppm-6.25 ppm and a decrease in turbidity 89 NTU-23.26 NTU. It is interesting to see an increase in DO in the underground treatment that is supposed to be anaerobic, this may indicate a lack of use or an oxygen leak of some kind. The fecal indicator bacteria *E. coli* also showed an odd result of an increase post treatment indicating treatment ineffectiveness. *E. coli* readings were 13.6 MPN/100mL in the influent and increased to 1200 MPN/100mL in the effluent. This may indicate that there is harboring bacteria in the underground up flow gravel treatment system or that the system is just not running optimally. This needs to be further investigated to see if the homes are actually hooked up and pumping water to the system as well as determining how the system has been maintained. In Report 1 when this system was last tested there was 1.5 MPN/100ML in the influent and zero bacteria in the effluent indicating little use of the system then. A follow up interview is required to know more.

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

<u>Photo Album</u>

Photo 19. Natalie testing turbidity of sample at the AIES CTWM Lab

Photo 20. 120mL water sample collecting bag for Compartment Bag Test (CBT) of *E. coli* and TC

Photo 21. 50mL sample conical for turbidity analysis back at the lab

Photo 22. Putting samples collected on ice for transport back to the lab

Photo 23. Natalie and Davis sampling in Marj Al Ghazal

Photo 24. In field sample equipment

Photo 25. Lab set up for Compartment Bag Test

Photo 26. Aquagenex CBT bag with label of site number and dilution

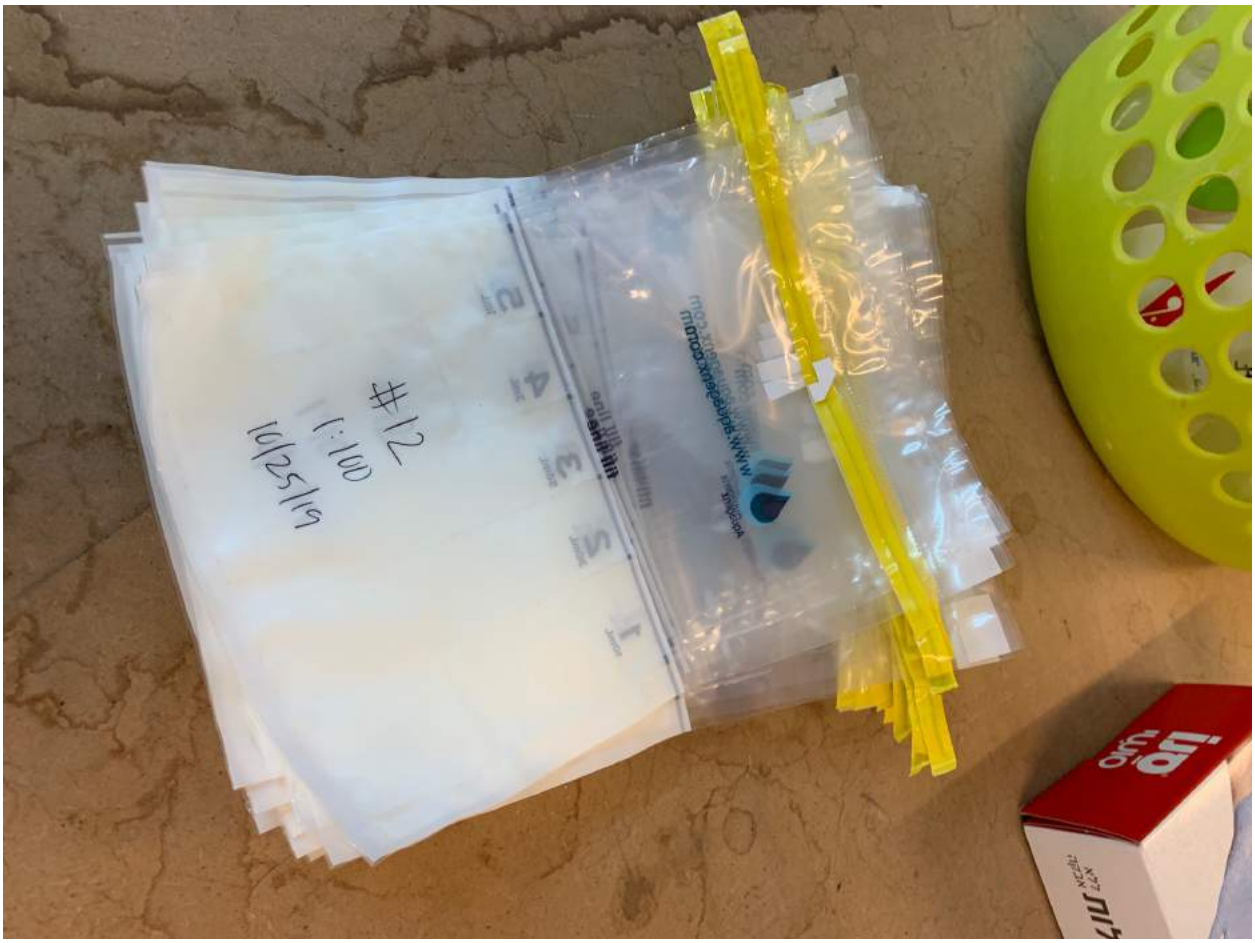

Photo 27. Field samples after dilution and media added before put into compartment bag

Photo 28. 120mL sample bag for dilution and bacteria media

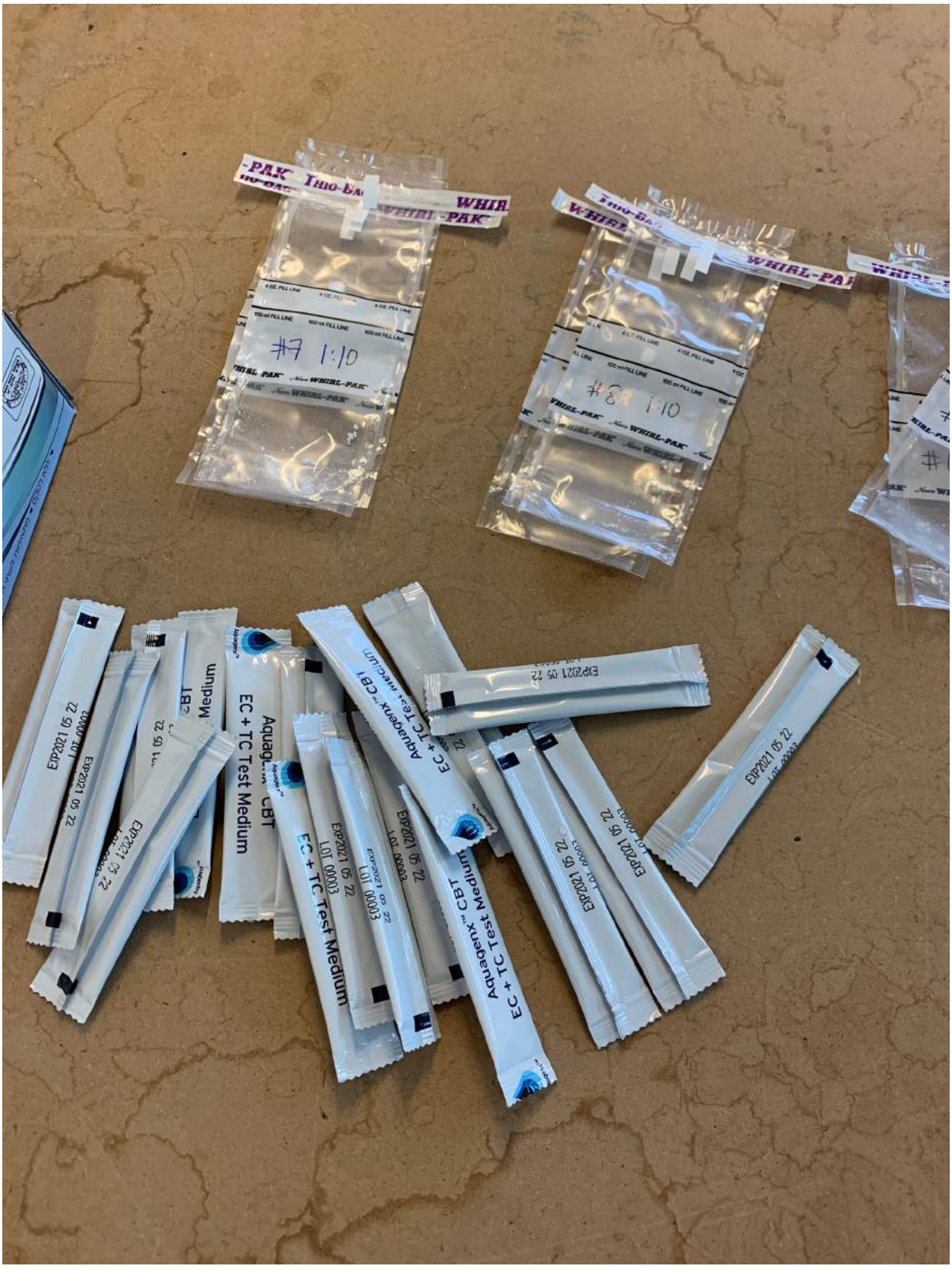

Photo 29. Dilutions equipment, graduated cylinder for 90mL and 99mL and DI battery water

Photo 30. Scientific workbench

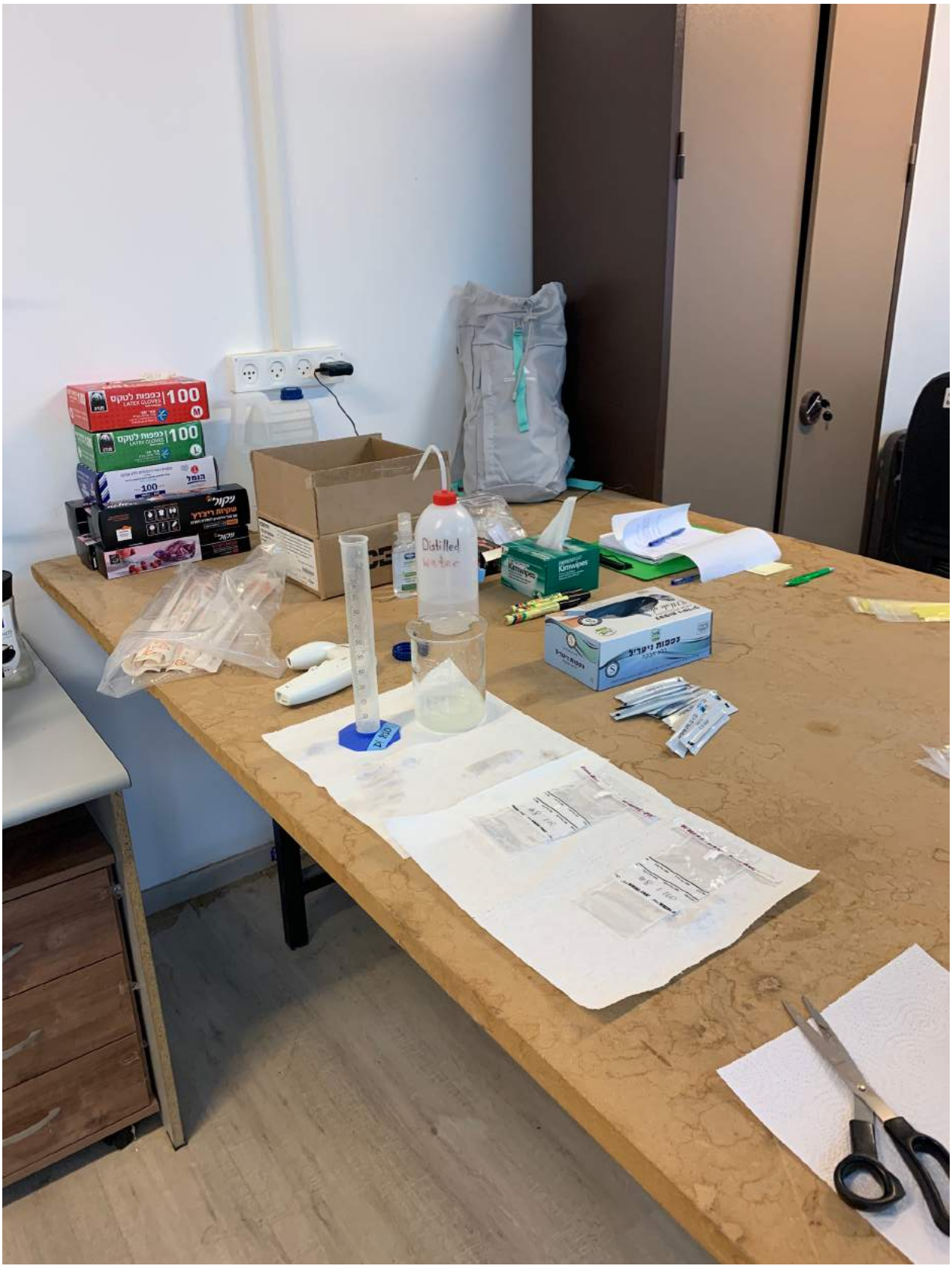

Photo 31. Turbidity workbench

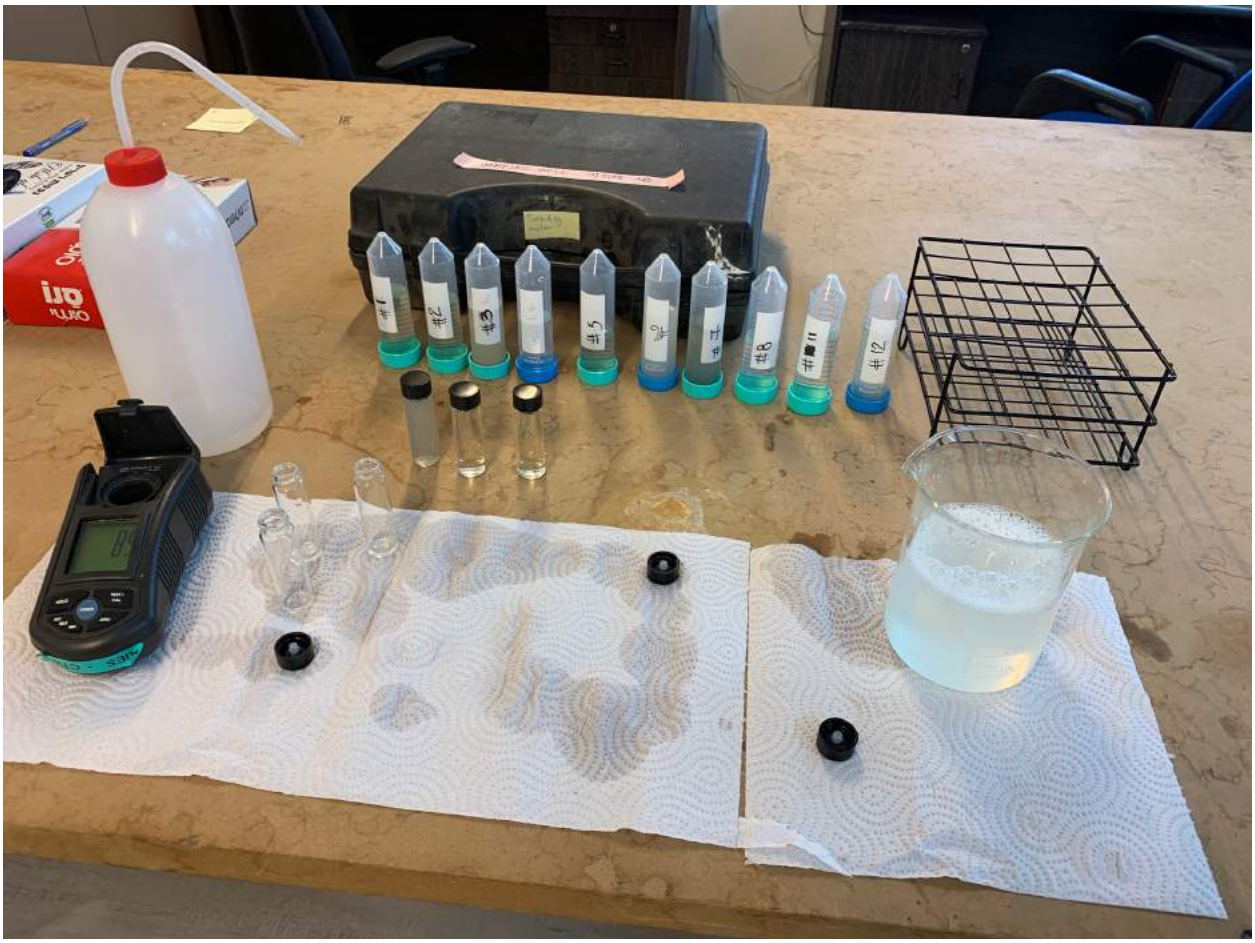

Photo 32. Compartment Bag Test post incubation with zero E. coli (no blue color change)

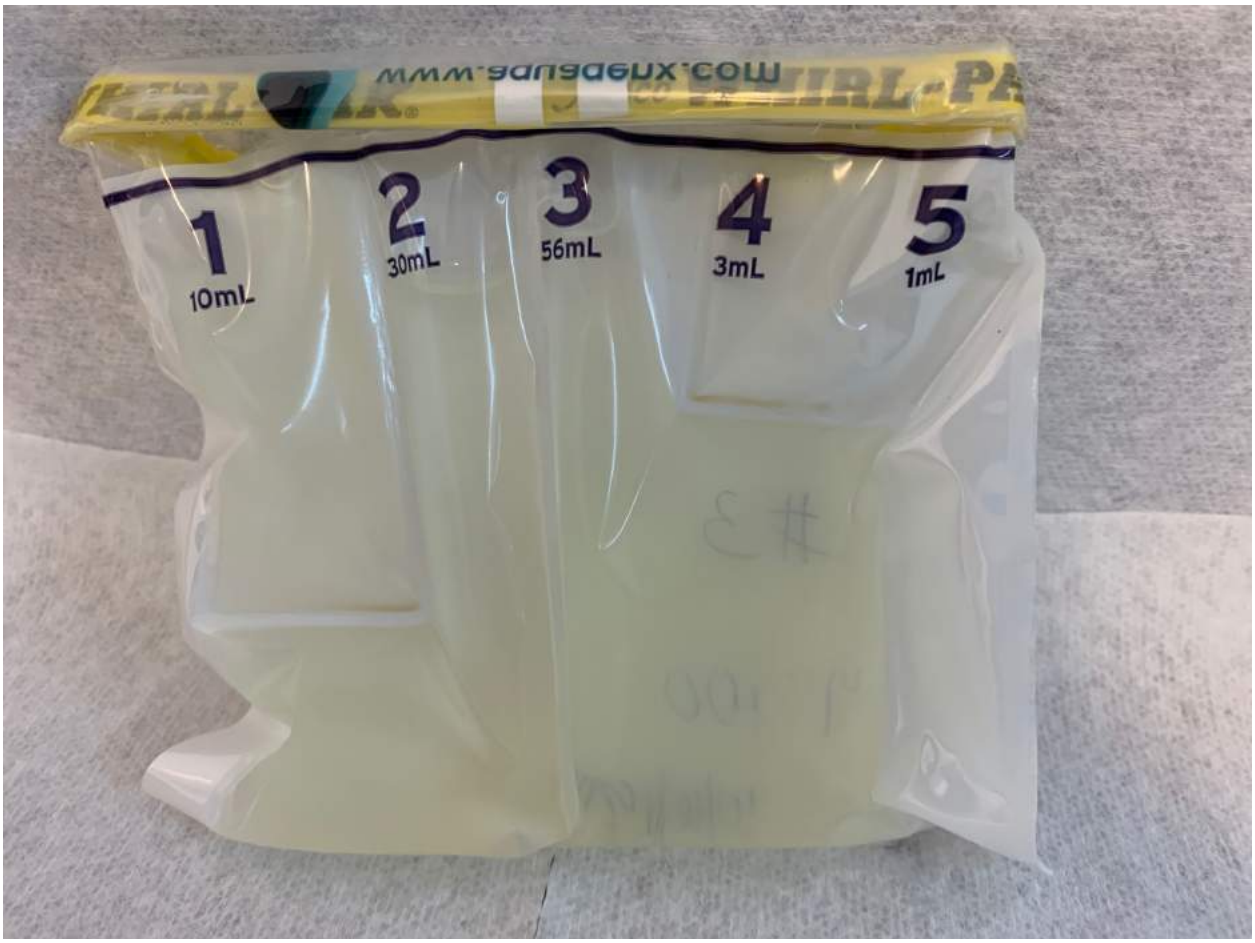

Photo 33. Compartment Bag Test post incubation with E. coli >100 MPN (blue color change)