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Physicochemical Investigation of Rainfall for Managed Aquifer Recharge in Punjab (Pakistan)

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Abstract: In a water-scarce country such as Pakistan, rainfall is the third-largest source of freshwater. In most of the urban cities of the country, rainwater is mixed with sewerage and is rendered useless for managed aquifer recharge purposes. Therefore, this study investigates the rainfall potential for managed aquifer recharge in Lahore (Pakistan). The present research was designed and conducted by the Irrigation Research Institute (IRI). Three different sites were selected for rainwater sample collection across the study area (Lahore), ranging from urban to rural areas. The rainwater samples were collected and divided into three categories (direct capture, rooftop runoff, street runoff). For longer rainfall events, the effect of time on the quality of the collected rainwater samples was also studied. Spatiotemporal trends of turbidity, pH, electrical conductivity, total dissolved solids, carbonates, bicarbonates, chloride, calcium, magnesium, and hardness in the collected rainwater samples were investigated. In terms of TDS, results indicated that directly captured rainwater is most suitable for managed aquifer recharge (TDS < 50 ppm), followed by rooftop runoff (TDS < 100 ppm). In addition, the quality of rainwater samples collected at the rural site was comparatively better. Moreover, the quality of rainwater samples improved after the initial ten minutes. All in all, this study concludes that direct capture of rainwater is the most suitable option for managed aquifer recharge.

Keywords: rainwater harvesting; groundwater recharge; Lahore; Pakistan

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1. Introduction

Groundwater accounts for roughly 30% of the earth's total fresh water, whereas surface water resources account for less than 0.3%. Demand for freshwater resources across the globe is noticeably increasing due to rapid industrialization and population growth. Hence, groundwater extraction has become an integral part of water management approaches, especially in rural areas. Areas with excessive groundwater extraction are now facing depleted groundwater reservoirs with hardly any recharge. Depletion of groundwater resources could lead to exhaustion of water in wells, streams, and lakes, deterioration of surface water quality, frequent land subsidence events, and higher pumping costs. Unsafe mixing of rainwater with sewerage leads to deteriorating surface water quality, which is rendered useless for managed aquifer recharge. To overcome this issue, artificial recharge sites could prove to be beneficial for managed aquifer recharge. However, the quality of the water leading into the recharge wells remains questionable. It has been reported that rainwater harvesting can promote significant water saving in residences in different countries. In Germany, Herrmann and Schmida [1] showed that the potential of potable water saving in a house varies from 30 to 60%, depending on the demand and roof area. In Australia, Coombes et al. [2,3] analyzed 27 rainwater samples and concluded that the use of rainwater would result in up to 60% savings in potable water use. In Brazil, Ghisi et al. [4,5] showed that the use of rainwater could potentially result in a 92% peak saving in potable water use. Additional potential sources of harvesting potable water from different sources include atmospheric water harvesting and other sources [6–22]. Gitte and Pendke [23] studied water conservation practices, water table fluctuations, and groundwater recharge in watershed areas. The study revealed that water conservation practices were found to be effective for raising the water table located in the middle and lower reach of the watershed. The overall groundwater recharge due to corresponding rainfall was in the range of 3.76 to 8.85 cm [24]. Kun Zhu et al. [19] investigated the rainwater quality in terms of WHO standards in the arid and semi-arid Loess Plateau of northern China. The study indicated that roof-yard catchments with the "first flush" provided safe rainwater with low organic contents immediately after rainfall. However, the rainwater collected from road surfaces had poor quality in terms of organic constituents regardless of the storage time. Esi Awuah et al. [25] concluded that rainwater could be safe for consumption in terms of all physicochemical parameters except microbial indicators. In Bangladesh, Rahman et al. [26] concluded that the overall quality of the rainwater is quite satisfactory as per Bangladesh standards. Keeping in view the above literature, rainwater is being used for various purposes, including managed aquifer recharge. However, the quality of the rainwater for managed aquifer recharge remains questionable.

To the best of the authors' knowledge, several studies have been undertaken to evaluate the rainfall potential for managed aquifer recharge. However, no specific study has been conducted highlighting the importance of the effect of physicochemical parameters of rainwater for aquifer recharge in Punjab (Pakistan). Therefore, this study aims to provide insights into the physicochemical investigation of rainwater for managed aquifer recharge in Lahore, Pakistan.

Under the current scenario and to check the quality status of rainwater, three sites, namely, IRI Lahore, FRS Babakwal, and ERS Thokar Niaz Beg Lahore, were selected for collection of rainwater samples from direct, street, and roof runoff.

2. Materials and Methods

2.1. Study Area

Lahore is located in northeast Pakistan and is the second-largest city in Pakistan in terms of population, with an annual population growth rate of 4.07%. It lies in a semi-arid climatic region with warm weather in summer. Monsoon (heavy rainfall season) usually starts in this region in late June. To investigate the quality of rainwater samples, three different sites were selected for rainwater sample collection across the city ranging from urban to rural areas. Recharge wells are installed at the study sites to investigate the physicochemical parameters of the collected rainwater samples. The rainwater samples were collected and divided into three categories (i.e., direct capture, rooftop runoff, street runoff). Details of the selected sites and their respective locations are presented in Table 1. Aerial maps of the study sites are presented in Figure 1. The profile of mean rainfall at the study sites is presented in Figure 2. According to Figure 2, monthly rainfall peaks at up to 307 mm/month during the monsoon season.

Table 1. Sample collection site locations in the study area.

Site No	Figure No.	Name of Site/Address	Location
Site 1 (S1)	Figure 1a	Irrigation Research Institute (IRI), Irrigation Department, Lahore, Pakistan	31.55 N, 74.31 E
Site 2 (S2)	Figure 1b	Experimental Research Station (ERS), Niazbeg, Lahore, Pakistan	31.47 N, 74.23 E
Site 3 (S3)	Figure 1c	Field Research Station (FRS) Babakwal, Tehsil Ferozewala District Sheikhupura	31.70 N, 74.36 E

Figure 1. Map of the study sites (**a**) S1—Irrigation Research Institute, Lahore, (**b**) S2—Experimental Research Station Niazbeg, Lahore, and (**c**) S3—Field Research Station, Babakwal.

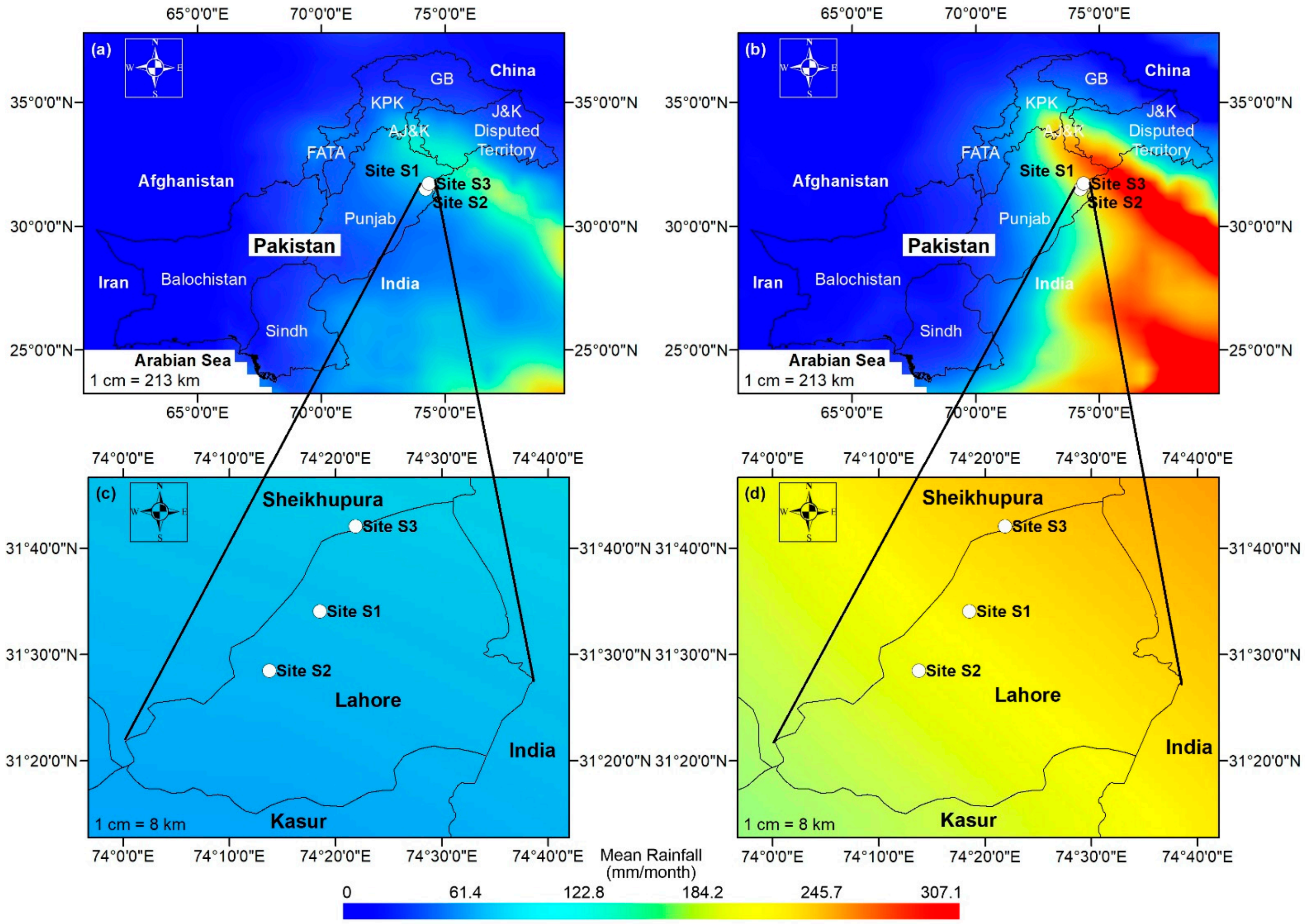

Figure 2. Profile of mean rainfall at the study sites where (**a**,**c**) represent June 2018, and (**b**,**d**) represent July 2018.

2.2. Sample Collection

A total of 140 different rainwater samples were collected from the three sites (Table A1) and categorized into three different sources of collection, namely direct capture, rooftop runoff, and street runoff. The rainwater samples were collected at 15 min time intervals during the respective rainfall event. Samples were collected separately into locally manufactured pre-cleaned high-density 500 mL polyethylene sampling bottles. The sampling bottles were sterilized and checked for any leakage. Gloves were used for proper handling of the collected rainwater samples. The collected rainwater samples were carefully labeled, organized, and immediately transported to the Chemical Laboratory of Engineering Material and Quality Control Section of Irrigation Research Institute (IRI), Lahore, for analyses. In case of any damage to the sample collection bottle during handling, a spare bottle was in place. The sampling procedure was performed according to the approved standards of the US Environmental Protection Agency (EPA).

2.3. Laboratory Analysis

The physiochemical parameters were detected from the collected samples, including pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), turbidity, carbonates, bicarbonates, chlorides, calcium plus magnesium, and hardness. pH was measured with the help of one of the most popular and splash-proof pH meters, i.e., HANNA model HI 8424 (Hanna Instruments, Inc., Smithfield, RI, USA). Its calibration is automated with three buffer values (4.01, 7.01, and 10.01) and it offers a resolution of 0.01 pH. EC (µs/cm) and TDS (ppm) were measured in situ with the help of Lovibond Senso Direct 150 m

(Tintometer Inc., Sarasota, FL, USA). Turbidity (NTU) was measured with an auto-ranging and high accuracy device, i.e., Lovibond Turbid Direct (Tintometer Inc., Sarasota, FL, USA), in situ. Carbonates, bicarbonates, chlorides, calcium plus magnesium, and hardness were determined in the Chemical Laboratory of the Engineering Material and Quality Control Section of Irrigation Research Institute, Lahore using standard laboratory protocols described by APHA [27].

3. Results

In Lahore, the start of the heavy rainfall monsoon season varies from late June to early July. In this regard, this study was designed to present rainfall events from late June to July. The results presented in the figures only represent indicative/ selective data to account for the monsoon season and for a better understanding of the spatiotemporal trends of the physicochemical parameters of collected rainwater samples. Extensive details of the collected data are presented in Tables A3–A11.

3.1. Site 1—IRI Department, Lahore

Results of analyses (presented in Figures 3–6) for Site 1 (S1) (i.e., Irrigation Research Institute, Irrigation Department Old Anarkali, Lahore, Pakistan) indicated that turbidity values of direct rain samples collected were in the range of 8.7 NTU to 19 NTU, while those from a rooftop in the range of 11.2 NTU to 22 NTU and of those samples collected from the street were in the range of 11.7 NTU to 64.2 NTU, as shown in Tables A2–A4. The pH of direct rainwater samples of seven events collected was in the range of 6.2 to 6.6, while those from a rooftop were in the range of 6.2 to 6.6. pH values of rainwater samples collected from the street were in the range of 6.2 to 6.7. It was found that the electrical conductivity of direct samples was in the range of 45.0 µs/cm to 143 µs/cm, while those collected from the rooftop and street rain samples were in the range of 63.0 to 177 µs/cm and 84.0 to 285 µs/cm, respectively. The Total Dissolved Solids (TDS) value found from direct rainfall samples was in the range of 22 to 71 ppm, while those collected from the rooftop were in the range of 31 to 88.0 ppm. TDS values of street rain samples were in the range of 42 to 142 ppm. It was observed that the chloride values of direct rain samples, rooftop rain samples, and street rain samples were in the range of 0.1 to 0.7 me/L, 0.1 to 0.5 me/L, and 0.2 to 0.7 me/L, respectively. Carbonate values of direct rain samples, rooftop rain samples and street rain samples were found to be nil. The results indicated that bicarbonate values of direct rain samples, rooftop rain samples and street rain samples were found to be in the range of 0.1 to 0.8 me/L, 0.2 to 0.5 me/L and 0.2 to 0.6 me/L, respectively. Calcium plus magnesium values of direct rain samples were found to be in the range of 0.2 to 1.0 me/L, while those collected from the rooftop and street rain samples were in the range of 0.3 to 1.3 me/L and 0.4 to 1.8 me/L, respectively. Total hardness values were observed in the range of 10 to 65 mg/L, 15 to 70 mg/L, and 20 to 90 mg/L for direct rain, rooftop and street rain samples, respectively, as shown in Tables A3–A5. Overall results of the analysis indicated that except for turbidity, all of the parameters were below the WHO recommendations for drinking water quality. Additionally, the in-detail results are presented in Appendix A.

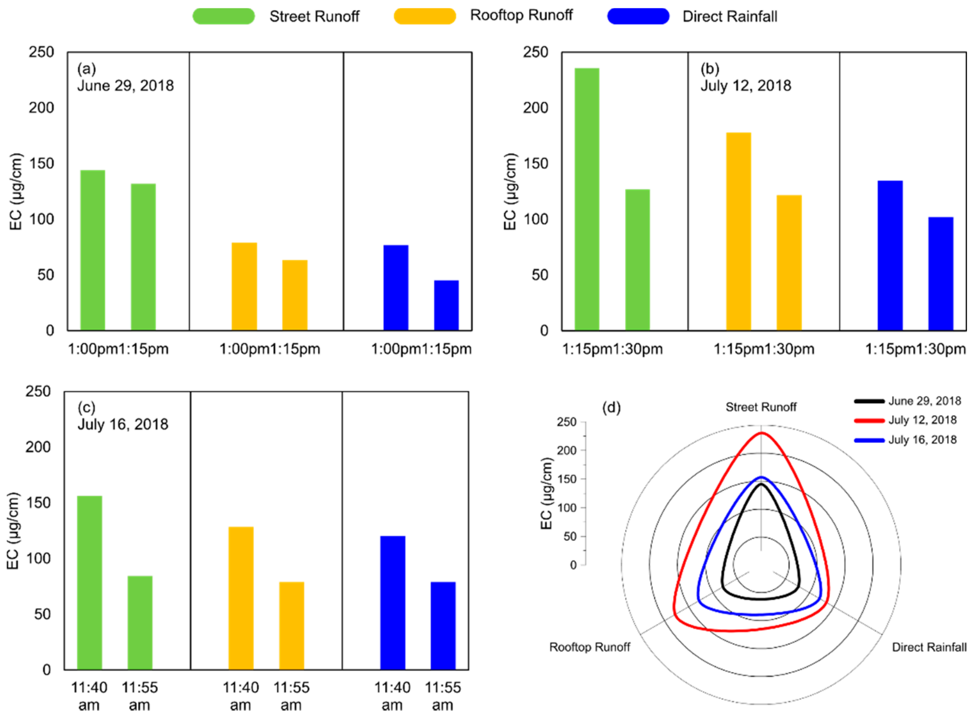

Figure 3. Profile of electrical conductivity (µg/cm) in harvested rainwater at Site S1—Irrigation Research Institute, Irrigation Department, Lahore, Pakistan, where (**a**) represents 29 June 2018, (**b**) represents 12 July 2018, (**c**) represents 16 July 2018, and (**d**) illustrates comparative analysis of the three selected dates on polar chart.

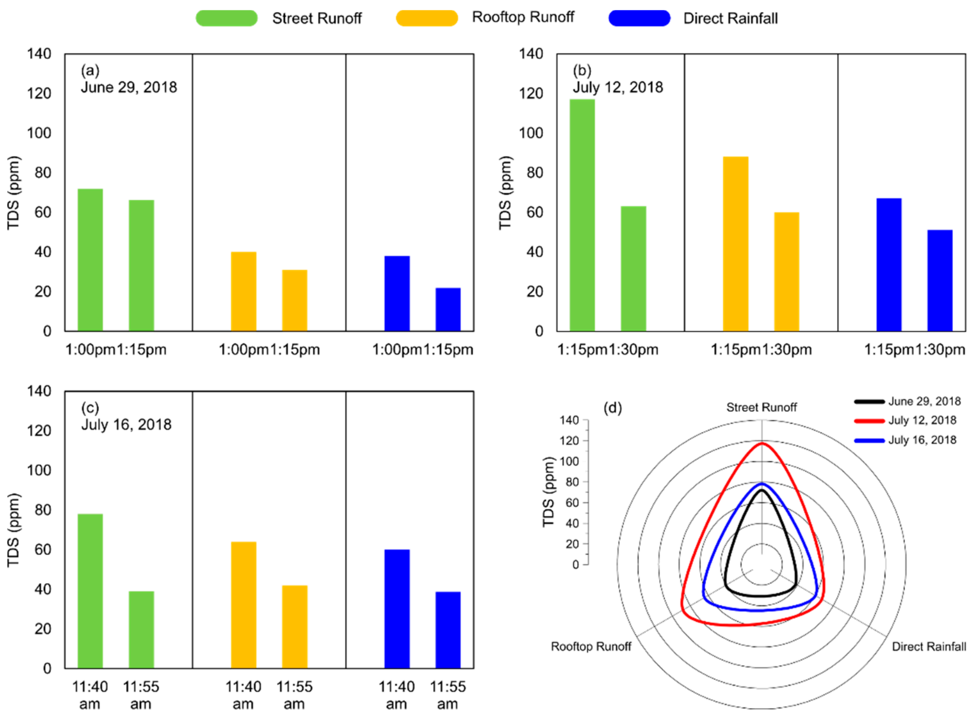

Figure 4. Profile of total dissolved solids (ppm) in harvested rainwater at Site S1—Irrigation Research Institute, Irrigation Department, Lahore, Pakistan, where (**a**) represents 29 June 2018, (**b**) represents 12 July 2018, (**c**) represents 16 July 2018, and (**d**) illustrates comparative analysis of the three selected dates on polar chart.

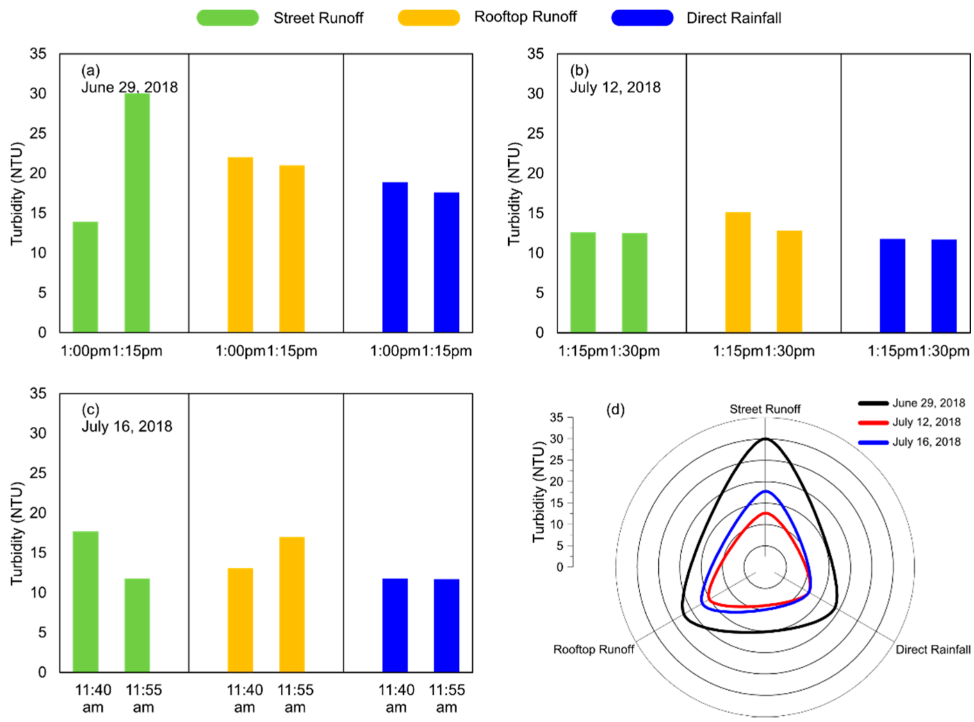

Figure 5. Profile of turbidity (NTU) in harvested rainwater at Site S1—Irrigation Research Institute, Irrigation Department, Lahore, Pakistan, where (**a**) represents 29 June 2018, (**b**) represents 12 July 2018, (**c**) represents 16 July 2018, and (**d**) illustrates comparative analysis of the three selected dates on polar chart.

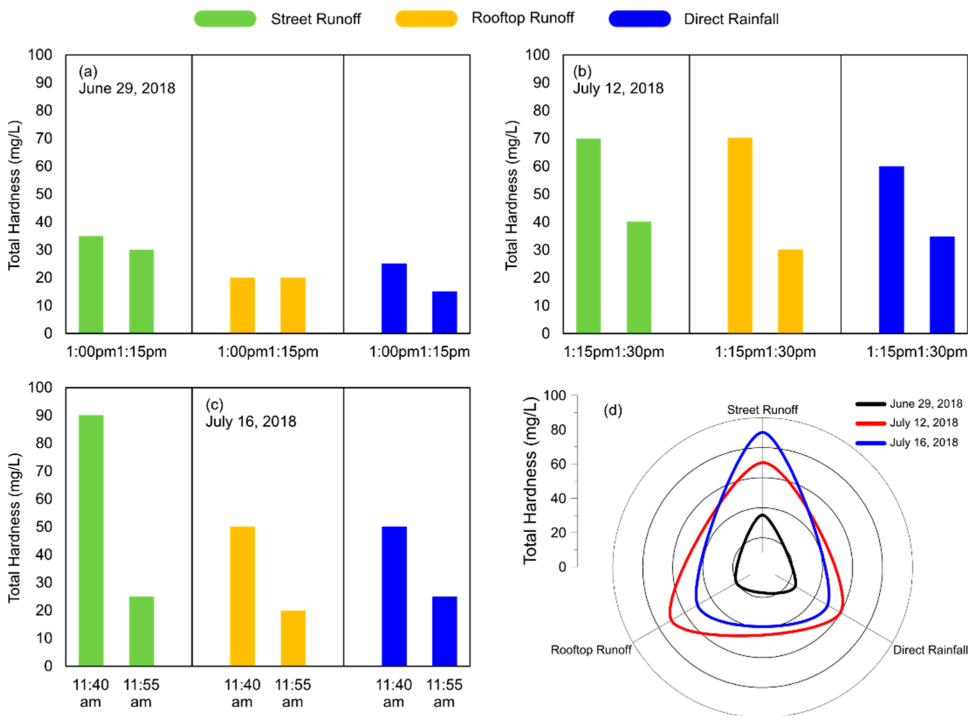

Figure 6. Profile of total hardness (mg/L) in harvested rainwater at Site S1—Irrigation Research Institute, Irrigation Department, Lahore, Pakistan, where (**a**) represents 29 June 2018, (**b**) represents 12 July 2018, (**c**) represents 16 July 2018, and (**d**) illustrates comparative analysis of the three selected dates on polar chart.

3.2. Site 2—Experimental Research Station (ERS), Lahore

Results of analyses (presented in Figure 7) for Site 2 (S2) (i.e., Experimental Research Station, Niazbeg, Lahore, Pakistan) showed that turbidity of direct rain was in the range of 10.3 to 20.0 NTU, the rooftop values ranged from 10.6 to 40.0 NTU and those of the street from 11.9 to 22.0 NTU. The pH of direct rainwater samples of five events collected was in the range of 6.4 to 6.6, while those on the rooftop were in the range of 6.4 to 6.6 and for the street, 6.4 to 6.6. The electrical conductivity of direct rainwater samples was in the range of 40.0 to 80.0 µs/cm, while those of rooftop rainwater samples ranged from 60.0 to 98.0 µs/cm and street rainwater samples, 72.0 to 214 µs/cm. Total Dissolved Solids (TDS) of direct rainfall samples were found in the range of 20.0 to 40.0 ppm, those of rooftop rainwater samples in the range of 30 to 49.0 ppm, and street rainwater samples ranged from 36 to 107 ppm. Chloride values of direct rainwater samples were found to be in the range of 0.1 to 0.3 me/L, while those of rooftop rainwater samples ranged from 0.1 to 0.6 me/L and street rainwater samples ranged from 0.1 to 1.2 me/L. Carbonate values for direct rainwater samples, rooftop rainwater samples, and street rainwater samples were found to be nil. Bicarbonate values of direct rainwater samples were observed in the range of 0.1 to 0.8 me/L, while those of rooftop rainwater samples ranged from 0.21 to 0.5 me/L and for street rainwater samples, 0.2 to 0.6 me/L. Calcium plus magnesium values of direct rainwater samples were in the range of 0.2 to 0.7 me/L, while those for rooftop rainwater samples ranged from 0.1 to 0.5 me/L and street rainwater samples, 0.2 to 0.7 me/L. Total Hardness analysis indicated that direct rainwater samples' values ranged from 10 to 35 mg/L, while those of rooftop rainwater samples ranged from 20 to 35 mg/L and street rainwater samples ranged from 20 to 65 mg/L. As indicated in Tables A5–A7, all the parameters except turbidity were below WHO, IBWA, PSQCA, and ISI drinking water criteria.

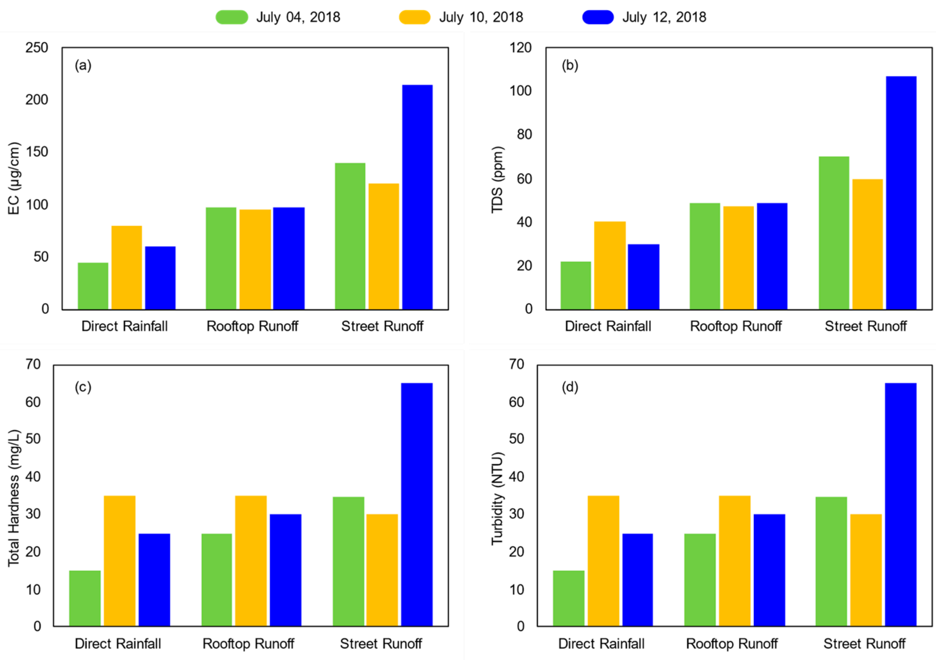

Figure 7. Inter-day profile of (**a**) electrical conductivity (µg/cm), (**b**) total dissolved solids (ppm), (**c**) total hardness (mg/L), and (**d**) turbidity (NTU) at Site S2—Experimental Research Station, Niazbeg, Lahore, Pakistan.

3.3. Site 3—Field Research Station (FRS), Babakwal

Results of analyses (presented in Figures 8–11) for Site 3 (S3) (i.e., Field Research Station Babakwal, Tehsil Ferozewala District Sheikhupura) showed that turbidity of direct rainwater samples ranged from 9.5 to 22.0 NTU, rooftop rainwater samples ranged from 10.0 to 24.7 NTU, while street rainwater samples ranged from 10.4 to 30.0 NTU. The pH of direct rainwater samples of six events collected ranged between 6.0 and 6.6, while for the rooftop it ranged from 6.3 to 6.7 and for the street it ranged from 6.0 to 6.6. Electrical conductivity analysis showed that its value for direct rainwater samples ranged from 30.0 to 140 µs/cm, while on the rooftop, rainwater samples ranged from 48.0 to 185 µs/cm and street rainwater samples ranged from 70.0 to 400 µs/cm. Total Dissolved Solids (TDS) analysis showed that direct rainwater sample values ranged from 15.0 to 70 ppm, while rooftop rainwater samples ranged from 24 to 92.0 ppm and street rainwater samples ranged from 35 to 200 ppm. Chloride analysis indicates that its value for direct rainwater samples ranged from 0.1 to 0.6 me/L, while rooftop rainwater samples ranged from 0.2 to 0.6 me/L and street rainwater samples ranged from 0.2 to 1.5 me/L. Carbonate analysis showed that its values for direct rainwater samples, rooftop rain samples and street rain samples were nil. The bicarbonate values of direct rainwater samples ranged from 0.1 to 0.7 me/L, while rooftop rainwater samples ranged from 0.1 to 0.4 me/L and street rainwater samples ranged from 0.2 to 1.0 me/L. The calcium plus magnesium values of direct rainwater samples ranged from 0.2 to 1.2 me/L, while rooftop rainwater samples ranged from 0.3 to 1.1 me/L and street rainwater samples ranged from 0.3 to 1.4 me/L. Total hardness analysis indicated that its value for direct rainwater samples ranged from 10 to 60 mg/L, while rooftop rainwater samples ranged from 15 to 55 mg/L and street rainwater samples ranged from 15 to 70 mg/L. All the parameters except turbidity were found below WHO drinking water limits, as shown in Tables A8–A10.

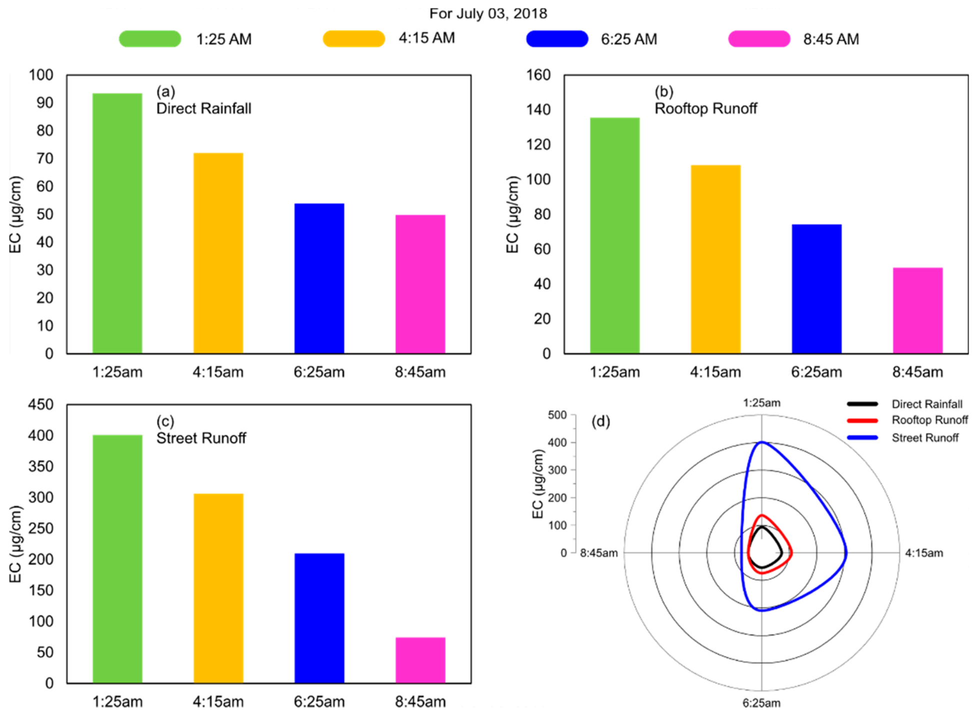

Figure 8. Intraday profile of electrical conductivity (µg/cm) (on 3 July 2018) at Site S3—Field Research Station Babakwal, Tehsil Ferozewala, District Sheikhupura, where (**a**) represents direct rainfall, (**b**) represents rooftop runoff, (**c**) represents street runoff, and (**d**) illustrates comparative analysis of the three selected categories on polar chart for different rainfall events.

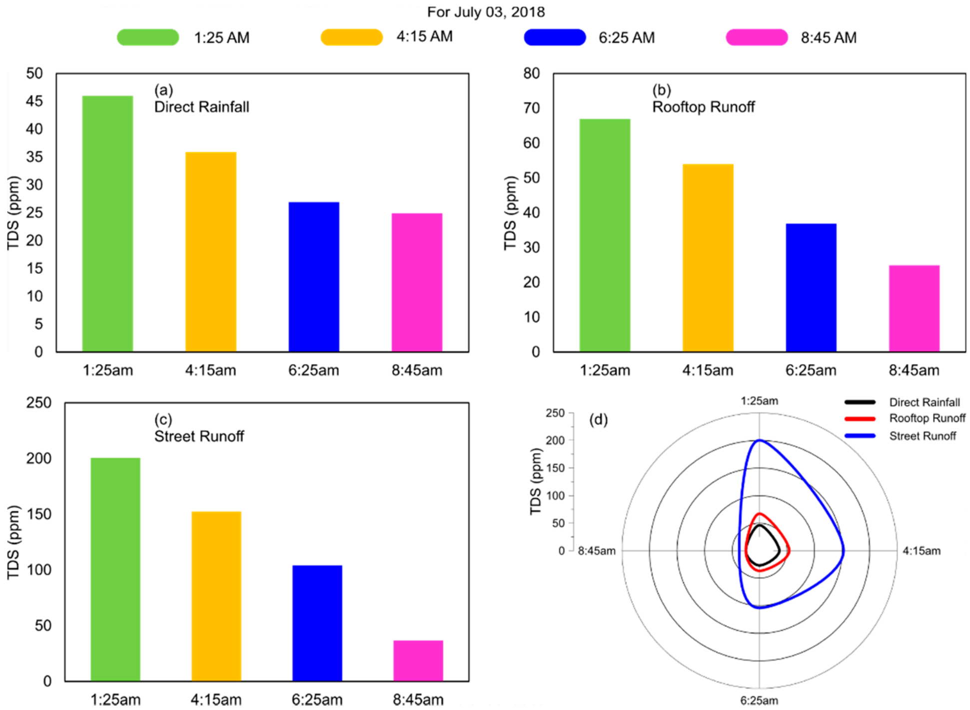

Figure 9. Intraday profile of total dissolved solids (ppm) (on 3 July 2018) at Site S3—Field Research Station Babakwal, Tehsil Ferozewala, District Sheikhupura, where (**a**) represents direct rainfall, (**b**) represents rooftop runoff, (**c**) represents street runoff, and (**d**) illustrates comparative analysis of the three selected categories on polar chart for different rainfall events.

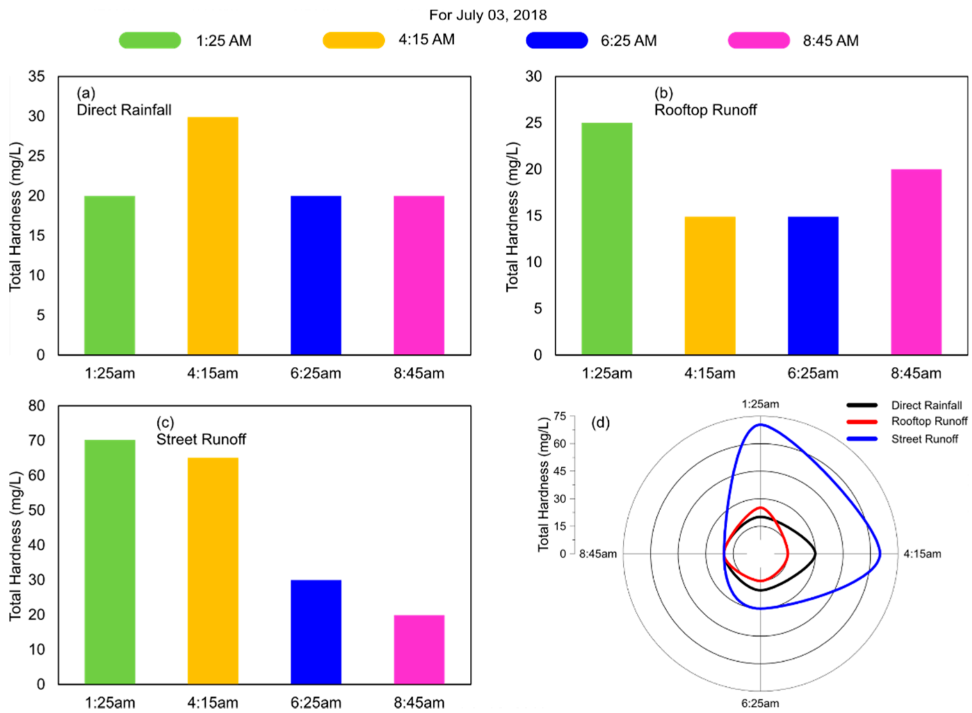

Figure 10. Intraday profile of total hardness (mg/L) (on 3 July 2018) at Site S3—Field Research Station Babakwal, Tehsil Ferozewala, District Sheikhupura, where (**a**) represents direct rainfall, (**b**) represents rooftop runoff, (**c**) represents street runoff, and (**d**) illustrates comparative analysis of the three selected categories on polar chart for different rainfall events.

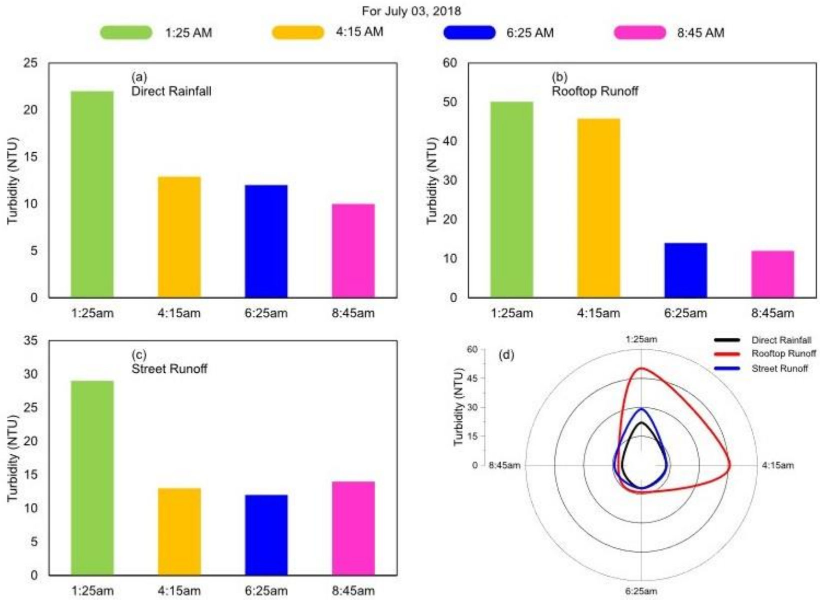

Figure 11. Intraday profile of turbidity (NTU) (on 3 July 2018) at Site S3—Field Research Station Babakwal, Tehsil Ferozewala, District Sheikhupura, where (**a**) represents direct rainfall, (**b**) represents rooftop runoff, (**c**) represents street runoff, and (**d**) illustrates comparative analysis of the three selected categories on polar chart for different rainfall events.

4. Discussion

The analysis of results from three sites (IRI, ERS Niazbeg, and FRS Babakwal) showed that the quality of rainfall water improves with time as rains continue. The collection of multiple samples (direct rainfall, rooftop runoff, and street runoff) showed that electrical conductivity, total dissolved solids, and turbidity decreased as the rain continued for hours. Additionally, no significant changes in pH were observed. Chemical analysis indicated that carbonates, bicarbonates, and chlorides were decreased in all types of samples. The quality of intraday rainwater increases due to the flash of all pollutants from our ecosystems but in inter-day rainwater samples, the quality almost remains the same due to the high risk of pollution that is created by anthropogenic activities. The overall quality of rainwater samples of the Irrigation Research Institute (IRI), Lahore, and ERS, Niazbeg is almost the same, while the quality of the FRS, Babakwal rainwater samples is much better because it exists in a rural area where the risk of environmental pollution is less than IRI and ERS due to less urbanization and industrialization. Therefore, the following recommendations are suggested. Demand for water resources is increasing day by day due to high population growth and expansion in urbanization and industrialization. Adopting the concept of sustainability and conservation of water resources can help to cope with the global water shortage. There is no denying that sustaining and recharging the groundwater along with the judicious use of the limited freshwater resources is the need of the hour. If sufficient measures are not taken up immediately, we will face a crisis that will be detrimental to the survival of mankind. Efficient management of water resources and education about judicious utilization of water resources along with measures of harnessing, recharging, and maintaining the quality of water and water bodies must be taken up on water footing. A rainwater harvesting system is one of the concepts that can be implemented to meet the water shortage problem. The quantity and quality of rainwater collected are different from place to place depending on the weather, geographic location, and anthropogenic activities in the area, in addition to the storage tanks. Furthermore, rainwater has a lot of potential as an alternative water resource for future use because of its high quality. Rainwater quality always exceeds the surface water and is comparable to groundwater because it does not encounter soil and rocks where it can dissolve salts and minerals, which are harmful for potable and non-potable uses. In addition, the recharging wells should be installed at a large scale so that managed aquifer recharge can be achieved. Successful implementation of rainwater harvesting system by agencies will be a great contribution to our ecosystem for future rainwater harvesting development and living quality [28]. Government agencies should play an important role in promoting this practice, such as offering incentives for fees of concerned authorities [29].

Limitations of the study include the fact that the average temperature in Lahore during the monsoon season is 40–45 °C. Such high temperatures lead to more than normal evaporation from the recharge sites, resulting in a limited supply of collected rainwater for managed aquifer recharge. In addition, the majority of the areas in Lahore are covered with buildings, pavements, and roads. Due to relatively more urbanized area, it is not feasible to install a number of recharge wells inside urban cities. Therefore, there is a pressing need to come up with a policy to install recharging wells in/around such areas for effectively managed aquifer recharge through rainwater.

5. Conclusions

The present study aimed to provide insights into the psychochemical investigation of rainfall for managed aquifer recharge in Punjab (Pakistan). The effect of psychochemical parameters of rainwater is usually not undertaken for managed aquifer recharge from recharge wells. Therefore, three different recharge-well sites were selected in this study. The collected rainwater samples were categorized into three different categories based on the source of collection, namely direct capture, rooftop runoff, and street runoff. The collected rainwater samples were analyzed in terms of pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), turbidity, carbonates, bicarbonates, chlorides, calcium plus magnesium, and hardness.

Turbidity levels of rainwater samples at Site 1 were 8.7–19, 11.2–22, and 11.7–64.2 NTU for direct capture, rooftop runoff, and street runoff. In a similar fashion, turbidity levels at Site 2 and Site 3 were (10.3–20, 10.6–40, and 11.9–22 NTU) and (9.5–22, 10–24.7, and 10.4–30 NTU). Similarly, pH levels at Sites 1, 2, and 3 were (6.2–6.6, 6.2–6.6, and 6.2–6.7), (6.4–6.6, 6.4–6.6, and 6.4–6.6), and (6–6.6, 6.3–6.7, and 6–6.6). In addition, the water quality of the direct capture rainfall samples was better compared to the rooftop and street runoff samples. Moreover, the water quality of intraday rainwater samples improved as the rain continued for hours as compared to inter-day rain. Additionally, the quality of rainwater samples collected at Site 3 was comparatively better. Thus, this study concludes that except for turbidity, all the physicochemical parameters were below the WHO, IBWA, PSQCA, and ISI water standards, and direct capture of rainwater is the most suitable option for managed aquifer recharge.

Author Contributions: Conceptualization, G.Z.-H.; methodology, G.Z.-H., J.F.P., G.S. and F.Y.; software, G.Z.-H. and H.A.; validation, G.Z.-H. and J.F.P.; formal analysis, J.F.P., G.S., F.Y. and H.A.; investigation, G.S., F.Y., M.S., F.M.; resources, G.Z.-H.; data curation, J.F.P., G.S. and F.Y.; writing—original draft preparation, G.Z.-H.; writing—review and editing, M.S., H.A., I.S. and F.M.; visualization, M.S., H.A., I.S. and F.M.; supervision, J.F.P. and M.S.; project administration, G.Z.-H. and G.S.; funding acquisition, G.Z.-H., I.S. and F.M. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Collection of rainwater samples from different sites.

Sr. No	Name of Station/Site	Sampling Duration	Type of Samples Collected	No. of Samples Collected
1	Irrigation Research Institute, Lahore (Site 1)	29–06–18 to 19–07–18	Direct Rainfall (DR)	17
			Roof Run off (RR)	13
			Street Run off (SR)	13
2	Field Research Station, Babakwal (Site 2)	29–06–18 to 21–07–18	Direct Rainfall (DR)	17
			Roof Run off (RR)	17
			Street Run off (SR)	17
			Groundwater Recharge Model (GR)	16
3	Experimental Research Station, Niazbeg (Site 3)	03–07–18 to 19–07–18	Direct Rainfall (DR)	9
			Roof Run off (RR)	11
			Street Run off (SR)	10
Total				140

Table A2. Drinking water criteria.

Parameter	Units	Permissible Limits				
		WHO	IBWA	PSQCA	USEPA	ISI
pH	-	6.5–8.5	-	6.5–8.5	6.5–8.5	6.5–8.5
TDS	(mg/L)	1000	500	500	-	-
Turbidity	(NTU)	5	-	0.5	-	10
Bicarbonate	(mg/L)	-	-	-	-	-
Carbonate	(mg/L)	-	-	-	-	-
Chloride	(meq/L)	7.042	7.042	7.042	7.042	5.633
Conductivity	(μS/cm)	-	-	-	-	-
Hardness	(mg/L)	-	-	-	-	300

Notes: - represents guidelines not given; WHO—World Health Organization; IBWA—International Bottled Water Association; PSQCA—Pakistan Standards and Quality Control Authority; USEPA—United State Environmental Protection Agency; ISI—Indian Standard Institute.

Table A3. Direct rain samples collected from Site 1.

Date	Rain Fall Event		Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
	Start Time	End Time											
29.06.18	1:00 p.m.	1:30 p.m.	1	1:00 p.m.	6.5	77.0	38.0	19.0	2.6	Nil	0.4	0.5	25.0
			2	1:15 p.m.	6.6	45.0	22.0	17.6	3.4	Nil	0.2	0.3	15.0
	3:25 p.m.	3:50 p.m.	1	3:35 p.m.	6.5	62.0	31.0	13.1	Nil	0.2	0.1	0.3	15.0
03.07.18	8:00 a.m.	8:40 a.m.	1	8:10 a.m.	6.5	180	90.0	18.7	Nil	0.8	0.7	1.3	65.0
			2	8:20 a.m.	6.5	80.0	40.0	16.2	Nil	0.3	0.4	0.3	15.0
			3	8:30 a.m.	6.5	80.0	40.0	11.2	Nil	0.3	0.5	0.2	10.0
	11:05 a.m.	11:45 a.m.	1	11:15 a.m.	6.5	70.0	35.0	11.8	Nil	0.2	0.3	0.3	15.0
			2	11:25 a.m.	6.5	68.0	34.0	12.5	Nil	0.3	0.3	0.3	15.0
			3	11:35 a.m.	6.6	62.0	37.0	10.2	Nil	0.2	0.2	0.2	10.0
12.07.18	1:00 p.m.	1:40 p.m.	1	1:17 p.m.	6.5	134	67.0	11.8	Nil	0.8	0.4	1.2	60.0
			2	1:30 p.m.	6.5	102	51.0	11.7	Nil	0.5	0.3	0.7	35.0
13.07.18	9:50 a.m.	10:15 a.m.	1	9:50 a.m.	6.5	99.0	49.0	8.7	Nil	0.5	0.3	0.4	20.0
16.07.18	11:40 a.m.	12:00 p.m.	1	11:45 a.m.	6.6	120	60.0	11.8	Nil	0.5	0.4	1.0	50.0
			2	11:55 a.m.	6.5	79.0	39.0	11.7	Nil	0.2	0.3	0.5	25.0
19.07.18	12:10 p.m.	12:50 p.m.	1	12:15 p.m.	6.3	143	71.0	14.7	Nil	0.2	0.4	0.7	35.0
			2	12:30 p.m.	6.2	85.0	42.0	12.0	Nil	0.2	0.2	0.3	15.0
			3	12:45 p.m.	6.2	60.0	30.0	10.3	Nil	0.1	0.3	0.3	15.0

Table A4. Rooftop rain samples collected from Site 1.

Date	Rain Fall Event		Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
	Start Time	End Time											
29.06.18	1:00 p.m.	1:30 p.m.	1	1:00 p.m.	6.6	79.0	40.0	22.0	Nil	0.3	0.2	0.4	20.0
			2	1:15 p.m.	6.5	63.0	31.0	21.0	Nil	0.3	0.2	0.4	20.0
29.06.18	3:25 p.m.	3:50 p.m.	1	3:30 p.m.	6.5	131	65.0	18.1	Nil	0.3	0.4	1.0	50.0
			2	3:45 p.m.	6.5	85.0	42.0	12.1	Nil	0.2	0.1	0.3	15.0
3.07.18	11:25 a.m.	11:40 a.m.	1	11:30 a.m.	6.4	95.0	47.0	16.1	Nil	0.3	0.4	1.0	50.0

Table A4. *Cont.*

Date	Rain Fall Event		Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
	Start Time	End Time											
12.07.18	1:00 p.m.	1:40 p.m.	1	1:19 p.m.	6.5	177	88.0	15.2	Nil	0.5	0.5	1.4	70.0
			2	1:30 p.m.	6.5	121	60.0	12.8	Nil	0.5	0.4	0.6	30.0
13.07.18	9:50 a.m.	10:15 a.m.	1	9:50 a.m.	6.6	106	53.0	12.0	Nil	0.4	0.3	0.7	35.0
16.07.18	11:35 a.m.	12:00 p.m.	1	11:40 a.m.	6.6	156	78.0	13.1	Nil	0.5	0.4	1.0	50.0
			2	11:50 a.m.	6.6	79.0	39.0	17.0	Nil	0.3	0.3	0.4	20.0
19.07.18	12:10 p.m.	12:50 p.m.	1	12:15 p.m.	6.2	150	75.0	14.9	Nil	0.2	0.4	0.6	30.0
			2	12:30 p.m.	6.2	103	51.0	12.5	Nil	0.2	0.2	0.5	25.0
			3	12:45 p.m.	6.2	66.0	33.0	11.2	Nil	0.1	0.2	0.4	20.0

Table A5. Street rain samples collected from Site 1.

Date	Rain Fall Event		Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
	Start Time	End Time											
29.06.18	1:00 p.m.	1:30 p.m.	1	1:00 p.m.	6.5	144	72.0	13.9	Nil	0.6	0.4	0.7	35.0
			2	1:15 p.m.	6.5	132	66.0	30.0	Nil	0.4	0.2	0.6	30.0
29.06.18	3:25 p.m.	3:50 p.m.	1	3:08 p.m.	6.4	285	142	17.9	Nil	0.3	0.3	0.7	35.0
			2	3:35 p.m.	6.4	226	113	64.7	Nil	0.4	0.3	0.9	45.0
3.07.18	11:25 a.m.	11:40 a.m.	1	11:30 a.m.	6.4	118	59.0	18.2	Nil	0.4	0.4	1.0	50.0
12.07.18	1:10 p.m.	1:35 p.m.	1	1:15 p.m.	6.7	235	117	12.6	Nil	0.6	0.7	1.4	70.0
			2	1:30 p.m.	6.7	127	63.0	12.5	Nil	0.5	0.5	0.8	40.0
13.07.18	10:30 a.m.	10:50 a.m.	1	10:45 a.m.	6.5	130	65.0	12.5	Nil	0.5	0.3	0.9	45.0
16.07.18	11:35 a.m.	11:55 a.m.	1	11:40 a.m.	6.6	128	64.0	17.7	Nil	0.5	0.3	1.8	90.0
			2	11:50 a.m.	6.5	84.0	42.0	11.7	Nil	0.3	0.2	0.5	25.0
19.07.18	12:10 p.m.	12:50 p.m.	1	12:15 p.m.	6.3	180	90.0	15.0	Nil	0.4	0.3	0.8	40.0
			2	12:30 p.m.	6.2	100	50.0	13.1	Nil	0.3	0.3	0.7	35.0
			3	12:45 p.m.	6.2	92.0	46.0	12.0	Nil	0.2	0.4	0.4	20.0

Table A6. Direct rain samples collected from Site 2.

Date	Rain Fall Event		Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
	Start Time	End Time											
03.07.18	10:15 a.m.	10:35 a.m.	1	10:30am	6.5	52.0	26.0	19.3	Nil	0.1	0.2	0.4	20.0
	12:10 p.m.	12:35 p.m.	2	12:30pm	6.5	50.0	25.0	17.0	Nil	0.1	0.3	0.2	10.0
	2:15 p.m.	2:35 p.m.	3	2:30pm	6.5	45.0	230	11.0	Nil	0.1	0.2	0.4	20.0
	4:15 p.m.	4:40 p.m.	4	4:30pm	6.5	42.0	210	10.3	Nil	0.2	0.1	0.3	15.0
4.07.18	1:25 a.m.	1:40 a.m.	1	1:30 a.m.	6.4	45.0	22.0	14.3	Nil	0.2	0.2	0.3	15.0
10.07.18	11:45 a.m.	12:45 p.m.	1	11:50 a.m.	6.5	80.0	40.0	16.7	Nil	0.2	0.3	0.7	35.0
12.07.18	12:15 p.m.	12:30pm	1	12:30 p.m.	6.6	60.0	30.0	15.9	Nil	0.2	0.2	0.5	25.0
19.07.18	12:05 p.m.	12:40 p.m.	1	12:15 p.m.	6.6	50.0	25.0	12.5	Nil	0.1	0.2	0.3	15.0
			2	12:30 p.m.	6.5	40.0	20.0	10.7	Nil	0.1	0.2	0.3	15.0

Table A7. Roof run off rain samples collected from Site 2.

Date	Rain Fall Event		Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
	Start Time	End Time											
03.07.18	5:45 a.m.	6:00 a.m.	1	5:50 a.m.	6.5	91.0	45.0	40.0	Nil	0.4	0.2	0.5	25.0
	8:25 a.m.	8:35 a.m.	2	8:30 a.m.	6.4	80.0	40.0	33.0	Nil	0.5	0.3	0.5	25.0
	10:15 a.m.	10:35 a.m.	3	10:30 a.m.	6.5	79.0	39.0	22.1	Nil	0.3	0.2	0.4	20.0
	11:15 a.m.	11:35 a.m.	4	11:30 a.m.	6.5	68.0	34.0	20.0	Nil	0.4	0.2	0.5	25.0
	12:10 p.m.	12:35 p.m.	5	12:30 p.m.	6.5	62.0	31.0	20.0	Nil	0.2	0.1	0.4	20.0
	1:50 p.m.	2:05 p.m.	6	2:00 p.m.	6.5	60.0	30.0	22.0	Nil	0.2	0.3	0.4	20.0
04.07.18	1:00 a.m.	1:20 a.m.	1	1:15 a.m.	6.6	98.0	49.0	18.1	Nil	0.2	0.1	0.5	25.0
10.07.18	11:45 a.m.	11:55 a.m.	1	11:50 a.m.	6.6	95.0	47.5	11.3	Nil	0.3	0.6	0.7	35.0
12.07.18	12:20 p.m.	12:40 p.m.	1	12:30 p.m.	6.6	98.0	49.0	10.6	Nil	0.4	0.3	0.6	30.0
19.07.18	12:05 p.m.	12:40 p.m.	1	12:15 p.m.	6.5	96.0	48.0	16.5	Nil	0.2	02	0.4	20.0
			2	12:30 p.m.	6.5	68.0	34.0	15.7	Nil	0.1	0.2	0.4	20.0

Table A8. Street run off rain samples collected from Site 2.

Date	Rain Fall Event Start Time	Rain Fall Event End Time	Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
03.07.18	5:45 a.m.	6:05 a.m.	1	5:50 a.m.	6.5	200	100	19.9	Nil	0.7	0.5	0.9	45.0
	7:35 a.m.	7:50 a.m.	2	7:40 a.m.	6.5	150	75.0	15.0	Nil	0.5	0.6	0.9	45.0
	10:15 a.m.	10:35 a.m.	3	10:30 a.m.	6.5	86.0	43.0	15.0	Nil	0.2	0.2	0.4	20.0
	11:15 a.m.	11:35 a.m.	4	11:30 a.m.	6.5	84.0	42.0	13.0	Nil	0.2	02	0.5	25.0
	12:10 p.m.	12:35 p.m.	5	12:30 a.m.	6.5	72.0	36.0	11.9	Nil	0.2	0.1	0.5	25.0
04.07.18	1:00 a.m.	1:25 a.m.	1	1:20 a.m.	6.4	140	70.0	22.0	Nil	0.5	0.4	0.7	35.0
10.07.18	11:45 a.m.	11:55 a.m.	1	11:50 a.m.	6.6	120	60.0	14.6	Nil	0.5	0.5	0.6	30.0
12.07.18	12:20 p.m.	12:40 p.m.	1	12:30 p.m.	6.6	214	107	16.6	Nil	0.4	1.2	1.3	65.0
19.07.18	12:05 p.m.	12:40 p.m.	1	12:15 p.m.	6.6	122	61.0	19.2	Nil	0.3	0.3	0.6	30.0
			2	12:30 p.m.	6.5	114	57.0	17.7	Nil	0.2	0.4	0.5	25.0

Table A9. Direct rain samples collected from Site 3.

Date	Rain Fall Event Start Time	Rain Fall Event End Time	Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
29.06.18	5:25 a.m.	6:30 a.m.	1	5:30 a.m.	6.5	140	70.0	18.5	Nil	0.7	0.6	1.2	60.0
			2	6:20 a.m.	6.5	65.0	33.0	10.5	Nil	0.2	0.2	0.4	20.0
	1:15 p.m.	2:05 p.m.	3	1:20 p.m.	6.6	50.0	25.0	10.8	Nil	0.3	0.2	0.4	20.0
			4	2:00 p.m.	6.5	35.0	17.0	12.8	Nil	0.1	0.1	0.4	20.0
30.06.18	5:30 a.m.	6:25 a.m.	1	5:45 a.m.	6.4	50.0	25.0	15.4	Nil	0.1	0.1	0.2	10.0
			2	6:20 a.m.	6.4	32.0	16.0	10.7	Nil	0.1	0.1	0.3	15.0
3.07.18	1:00 a.m.	1:25 a.m.	1	1:15 a.m.	6.4	93.0	46.0	22.0	Nil	0.2	0.1	0.5	20.0
	3:55 a.m.	4:15 a.m.	2	4:00 a.m.	6.4	72.0	36.0	12.7	Nil	0.2	0.1	0.6	30.0
	6:15 a.m.	6:25 a.m.	3	6:20 a.m.	6.3	54.0	27.0	12.5	Nil	0.2	0.2	0.4	20.0
	7:55 a.m.	8:45 a.m.	4	8:00 a.m.	6.3	50.0	25.0	10.1	Nil	0.2	0.1	0.4	20.0
			5	8:40 a.m.	6.3	30.0	15.0	10.0	Nil	0.1	0.1	0.2	10.0
13.07.18	9:15 a.m.	10:15 a.m.	1	9:30 a.m.	6.2	100	50.0	16.3	Nil	0.4	0.3	0.4	20.0
			2	10:00 a.m.	6.0	50.0	25.0	12.8	Nil	0.2	0.2	0.5	25.0
17.07.18	1:35 p.m.	2:30 p.m.	1	1:45 p.m.	6.6	97.0	48.0	16.3	Nil	0.3	0.3	0.4	20.0
			2	2:15 p.m.	6.5	66.0	33.0	15.7	Nil	0.2	0.2	0.2	10.0
21.07.18	4:50 p.m.	5:45 p.m.	1	5:00 p.m.	6.6	78.0	39.0	13.3	Nil	0.2	0.3	0.5	25.0
			2	5:30 p.m.	6.5	46.0	23.0	9.5	Nil	0.1	0.2	0.2	10.0

Table A10. Roof run off rain samples collected from Site 3.

Date	Rain Fall Event		Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
	Start Time	End Time											
29.06.18	5:25 a.m.	6:30 a.m.	1	5:30 a.m.	6.6	185	92.0	16.3	Nil	0.4	0.6	1.1	55.0
			2	6:20 a.m.	6.6	125	62.0	13.4	Nil	0.4	0.5	0.8	40.0
	1:15 p.m.	2:05 p.m.	3	1:20 p.m.	6.7	99.0	50.0	17.1	Nil	0.2	0.2	0.6	30.0
			4	2:00 p.m.	6.6	89.0	45.0	14.8	Nil	0.4	0.2	0.4	20.0
30.06.18	5:30 a.m.	6:25 a.m.	1	5:45 a.m.	6.5	100	50.0	24.7	Nil	0.3	0.4	0.3	15.0
			2	6:20 a.m.	6.6	76.0	38.0	11.4	Nil	0.2	0.2	0.5	25.0
3.07.18	1:00 a.m.	1:25 a.m.	1	1:15 a.m.	6.5	135	67.0	10.2	Nil	0.3	0.5	0.5	25.0
	3:55 a.m.	4:15 a.m.	2	4:00 a.m.	6.6	108	54.0	16.2	Nil	0.3	0.3	0.3	15.0
	6:15 a.m.	6:25 a.m.	3	6:20 a.m.	6.5	74.0	37.0	13.7	Nil	0.2	0.3	0.3	15.0
	7:55 a.m.	8:45 a.m.	4	8:00 a.m.	6.5	50.0	25.0	11.9	Nil	0.2	0.3	0.4	20.0
			5	8:40 a.m.	6.5	48.0	24.0	10.0	Nil	0.1	0.3	0.3	15.0
13.07.18	9:15 a.m.	10:15 a.m.	1	9:30 a.m.	6.4	142	71.0	14.4	Nil	0.3	0.3	0.8	40.0
			2	10:00 a.m.	6.3	77.0	38.0	17.7	Nil	0.2	0.2	0.6	30.0
17.07.18	1:35 p.m.	2:30 p.m.	1	1:45 p.m.	6.5	163	81.0	13.9	Nil	0.3	0.4	0.7	35.0
			2	2:15 p.m.	6.4	157	78.0	10.3	Nil	0.4	0.5	0.6	30.00

Table A11. Street run off rain samples collected from Site 3.

Date	Rain Fall Event		Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
	Start Time	End Time											
29.06.18	5:25 a.m.	6:30 a.m.	1	5:30 a.m.	6.6	190	95.0	30.0	Nil	0.3	1.2	1.2	60.0
			2	6:20 a.m.	6.5	140	70.0	22.0	Nil	0.2	0.8	0.8	40.0
	1:15 p.m.	2:05 p.m.	3	1:20 p.m.	6.5	100	50.0	20.0	Nil	0.2	0.3	0.8	40.0
			4	2:00 p.m.	6.5	98.0	49.0	15.0	Nil	0.2	0.2	0.7	35.0
30.06.18	5:30 a.m.	6:25 a.m.	1	5:45 a.m.	6.5	163	81.0	18.0	Nil	0.3	0.4	0.5	25.0
			2	6:20 a.m.	6.4	90.0	45.0	11.0	Nil	0.2	0.2	0.6	30.0

Table A11. *Cont.*

Date	Rain Fall Event		Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
	Start Time	End Time											
03.07.18	1:00 a.m.	1:25 a.m.	1	1:15 a.m.	6.6	400	200	29.5	Nil	0.5	1.5	1.4	70.0
	3:55 a.m.	4:15 a.m.	2	4:00 a.m.	6.5	307	153	13.5	Nil	0.4	0.7	1.3	65.0
	6:15 a.m.	6: 30 a.m.	3	6:20 a.m.	6.5	209	104	12.1	Nil	0.4	0.5	0.6	30.0
	7:55 a.m.	8:45 a.m.	4	8:00 a.m.	6.4	74.0	37.0	14.9	Nil	0.2	0.2	0.4	20.0
			5	8:40 a.m.	6.3	70.0	35.0	14.7	Nil	0.2	0.3	0.3	15.0
13.07.18	9:15 a.m.	10:15 a.m.	1	9:30 a.m.	6.1	350	175	13.3	Nil	0.3	1.5	2.0	100
			2	10:00 a.m.	6.0	115	57.0	13.1	Nil	0.3	0.4	1.2	60.0
17.07.18	1:35 p.m.	2:30 p.m.	1	1:45 p.m.	6.5	344	172	18.9	Nil	0.5	0.8	1.3	65.0
			2	2:15 p.m.	6.2	207	103	18.4	Nil	1.0	0.6	1.2	60.0
21.07.18	4:50 p.m.	5:45 p.m.	1	5:00 p.m.	6.5	150	75.0	22.2	Nil	0.3	0.5	0.7	35.0
			2	5:30 p.m.	6.4	88.0	44.0	10.4	Nil	0.2	0.3	0.4	20.0

Table A12. Rain harvesting model samples collected from Site 3.

Date	Rain Fall Event		Samples Collected	Sampling Time	PH	EC (µs/cm)	TDS (ppm)	Turbidity (NTU)	CO_3^- (me/L)	HCO_3^- (me/L)	Cl^- (me/L)	$Ca^{+2} + Mg^{+2}$ (me/L)	Total Hardness (mg/L)
	Start Time	End Time											
29.06.18	5:25 a.m.	6:30 a.m.	1	5:30 a.m.	6.6	370	185	75.3	Nil	0.5	0.3	0.8	40.0
			2	6:20 a.m.	6.5	367	183	39.8	Nil	0.4	0.3	1.0	50.0
	1:15 p.m.	2:05 p.m.	3	1:20 p.m.	6.5	425	212	68.9	Nil	0.4	0.4	1.2	60.0
			4	2:00 p.m.	6.4	525	262	70.2	Nil	0.8	0.5	1.3	65.0
30.06.18	1:15 p.m.	2:05 p.m.	1	2:00 p.m.	6.5	165	83.0	52.0	Nil	0.4	0.3	0.4	20.0
03.07.18	1:00 a.m.	1:25 a.m.	1	1:15 a.m.	6.5	204	102	13.2	Nil	0.4	0.4	0.4	20.0
	3:55 a.m.	4:15 a.m.	2	4:00 a.m.	6.5	214	107	14.7	Nil	0.3	0.5	0.6	30.0
	6:15 a.m.	6: 30 a.m.	3	6:20 a.m.	6.5	166	83.0	25.8	Nil	0.4	0.4	0.5	25.0
	7:55 a.m.	8:45 a.m.	4	8:00 a.m.	6.4	165	82.0	36.3	Nil	0.3	0.3	0.5	25.0
			5	8:40 a.m.	6.4	142	71.0	12.4	Nil	0.3	0.4	0.4	20.0
13.07.18	9:15 a.m.	10:15 a.m.	1	9:30 a.m.	6.2	1243	621	17.8	Nil	2.4	3.0	4.5	225
			2	10:00 a.m.	6.0	454	227	13.6	Nil	0.3	0.7	1.4	70.0
17.07.18	1:35 p.m.	2:30 p.m.	1	1:45 p.m.	6.2	821	410	12.5	Nil	0.8	1.0	2.8	140
			2	2:15 p.m.	6.0	745	372	10.0	Nil	2.0	1.2	2.2	110
21.07.18	4:50 p.m.	5:45 p.m.	1	5:00 p.m.	6.6	550	275	19.9	Nil	0.5	0.8	1.2	60.0
			2	5:30 p.m.	6.5	238	119	11.1	Nil	0.5	0.6	0.8	40.0

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