COMSATS University Vehari

Agriculture Urbaine au Pakistan: La gestion de l'arsenic dans les écosystèmes et la chaîne alimentaire

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Overview of presentation

- Agriculture in Pakistan (Peri-Urban agriculture)
- Issue of untreated wastewater use for crop irrigation in Pakistan
- Arsenic ground/drinking water dilemma in Pakistan

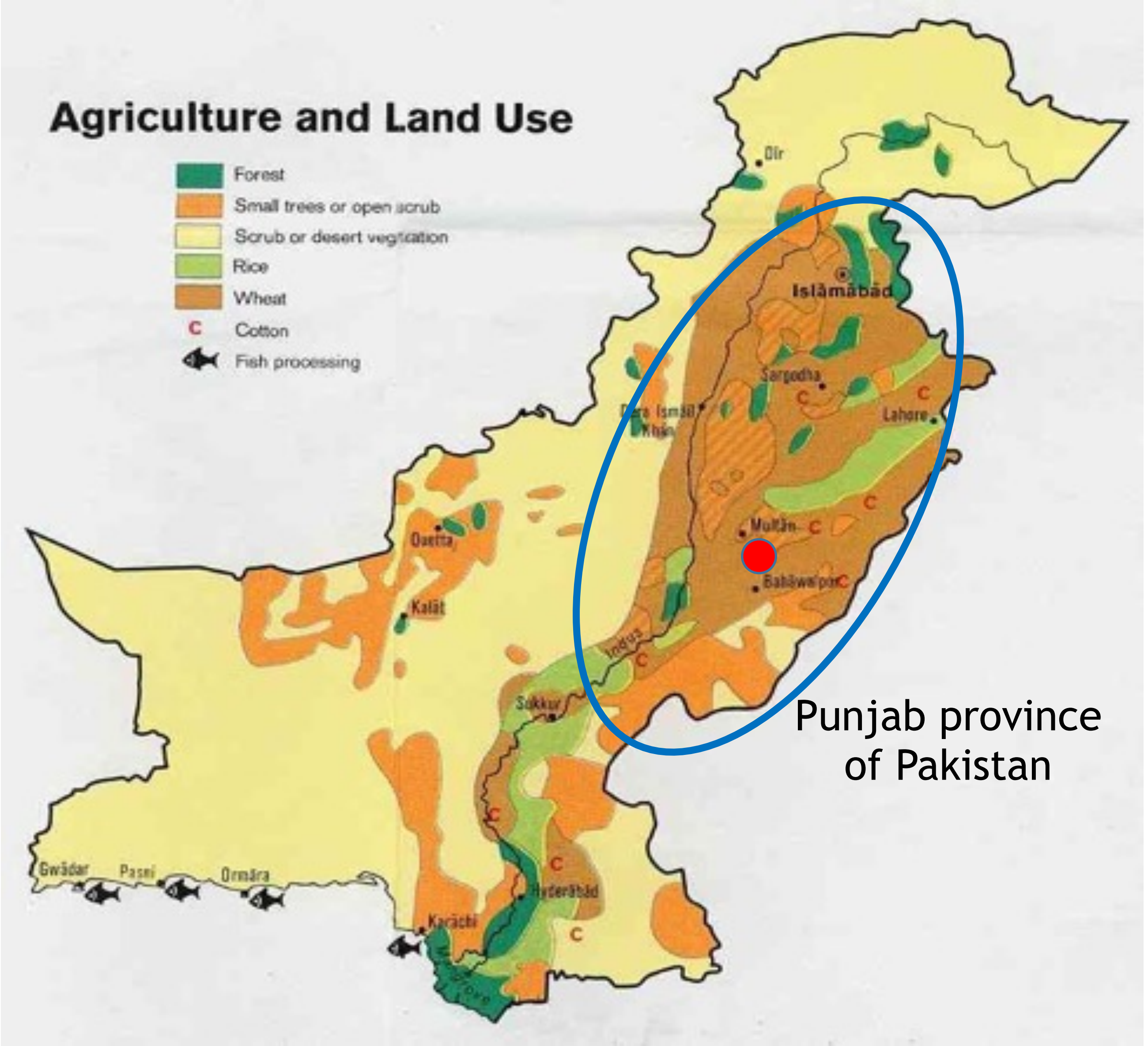
Agriculture Urbaine au Pakistan

Facts of Pakistan's agriculture sector

- Pakistan is the **6th** most heavily populated country in the world with a population of **208 million**
- Pakistan is an agriculture-based country
- Agricultural sector contributes about **24% to GDP** and employs **47% of the labor** force of Pakistan..
- ~**15-20%** of the food requirement are met by urban/peri-urban cultivation

Area under cultivation in Pakistan

Country/ Province	Total area (million hectares)	Cultivated area (million hectares)
Pakistan	**79.6**	**22.04**
Punjab	20.63	**12.51**
Sindh	14.09	5.03
KPK	10.17	1.87
Baluchistan	34.74	2.63



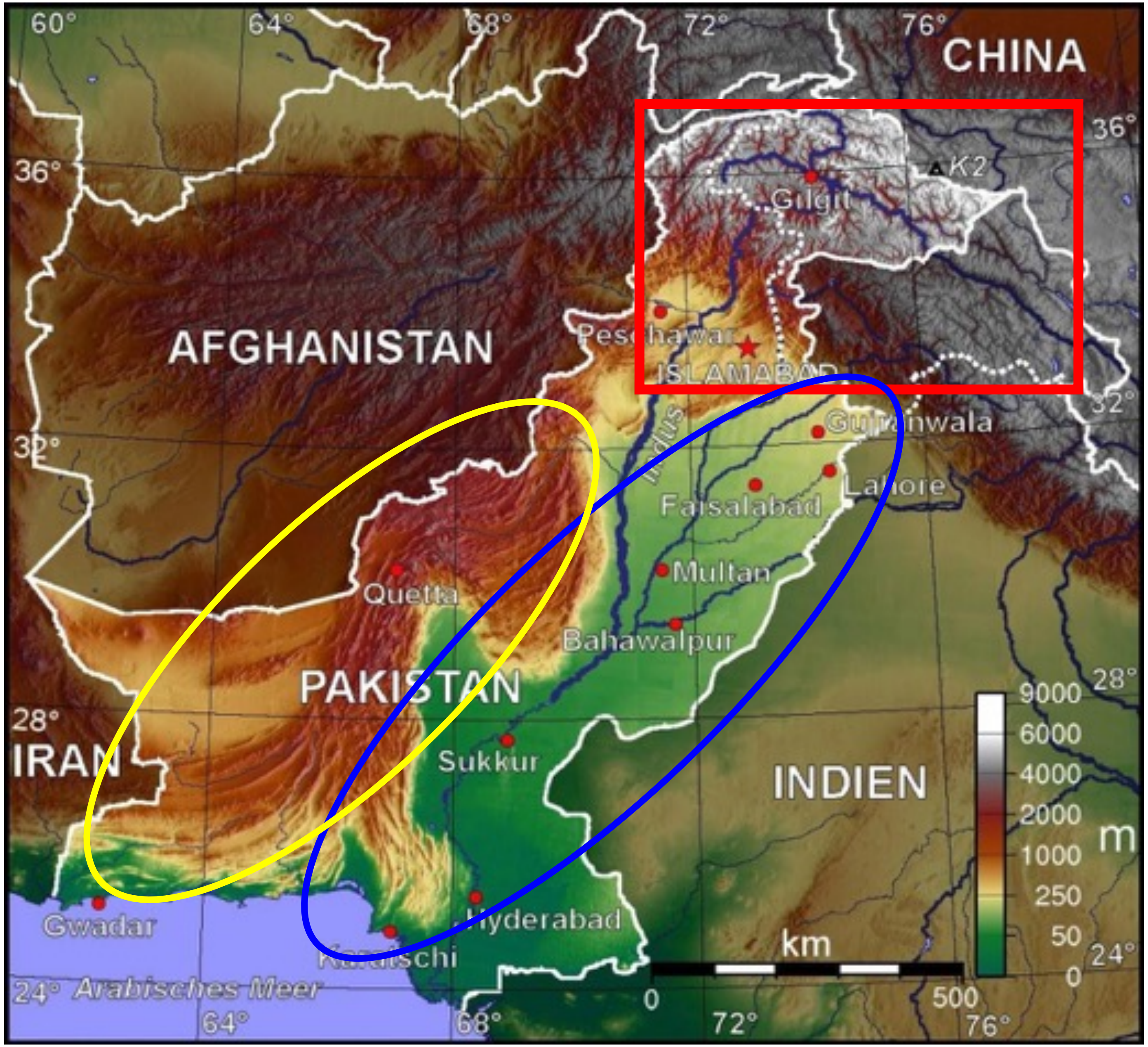
Climate of Pakistan

- Pakistan has four seasons a year

- Spring (Feb-March) (30-40 °C)
- Summer (March-August) (40-50 °C)
- Autumn (Sept-Oct) (30-40 °C)
- Winter (Dec-Jan) (5-30 °C)

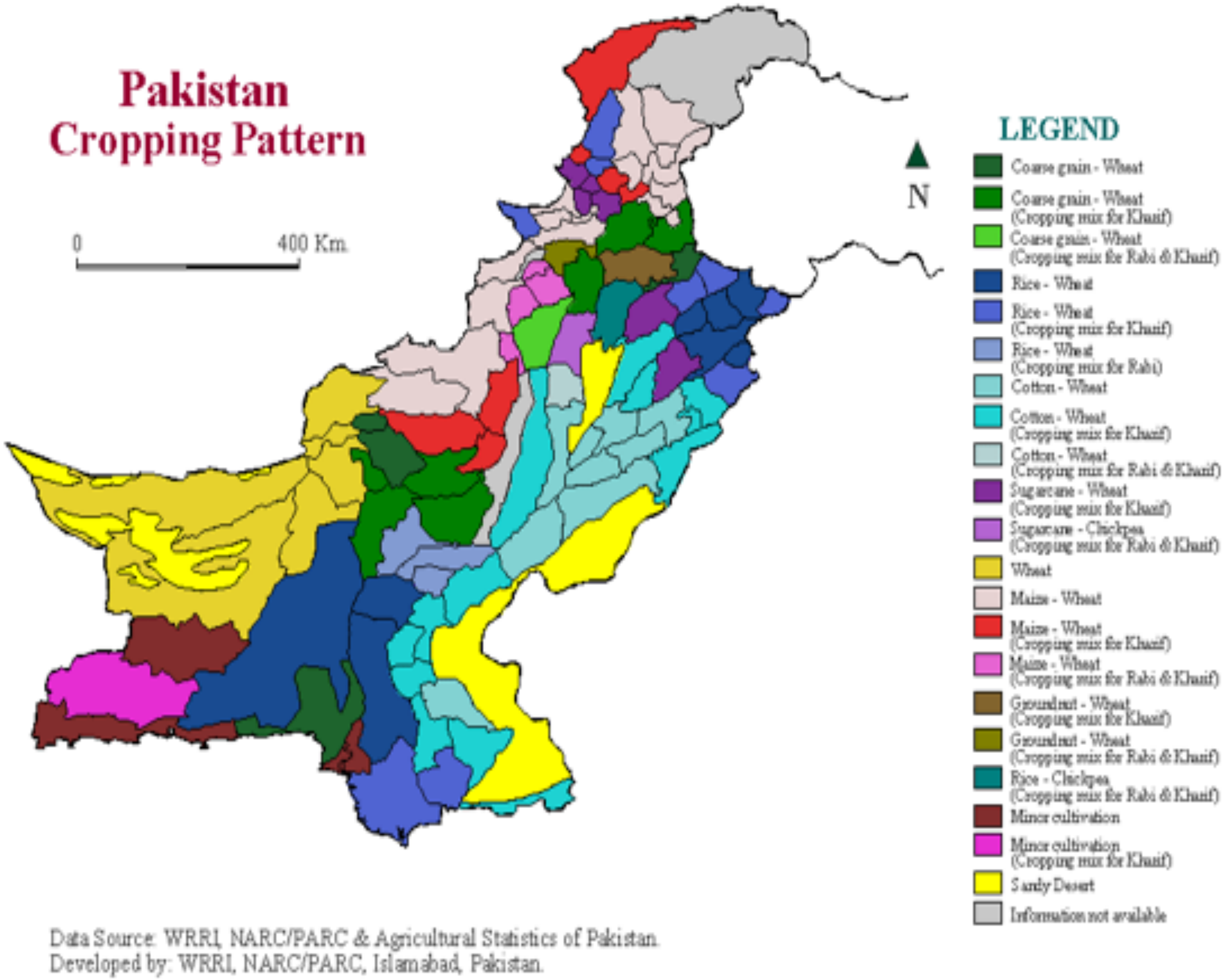
- Monsoon Rainy Period (July-September)

Topography of Pakistan and agriculture



Cropping Pattern in Pakistan

Vegetables		Crops
Carrot	Fenugreek	**Wheat**
Cauliflower	Garlic	**Maize**
Cabbage	Bell paper	Barley
Radish	Okra	**Cotton**
Spinach	Onion	Sugarcane
Tomato	Pea	**Rice**
Turnip	Coriander	Sorghum
Brinjal	Bitter gourd	Mustard
Chili	Cucumber	



PERI-URBAN AGRICULTURE

Peri-urban agriculture is more dominant in Pakistan compared to urban agriculture

Khalid et al. 2018 Int. J. Environ. Res. Public H

Peri-urban agriculture in Pakistan

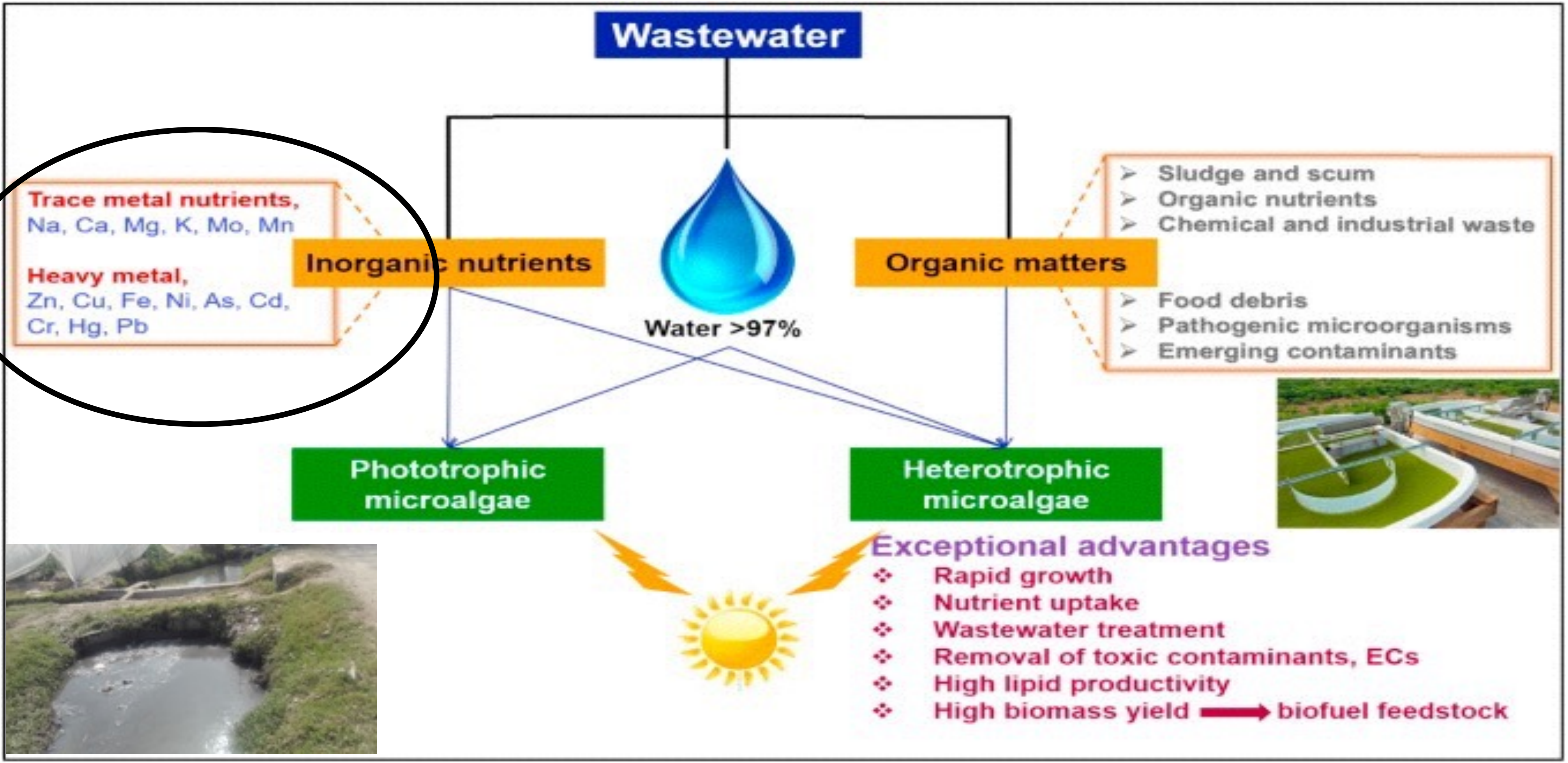
- **Vegetables**
- Cereals
- Crops
- Ornamental Trees
- Aromatic Vegetables

Mode of irrigation for Peri-urban agriculture in Pakistan

- Canals (best system in the world)
- Tube wells (groundwater)
- Wastewater (most importantly)

Why Wastewater? – A basic fertilizer

Wastewater can reduce the need for the application of fertilizers in Peri-urban Farming.



Use of urban wastewater in Pakistan: Facts and stat

- ✓ 64% of wastewater is directly discharged into water bodies without any pretreatment
- ✓ Approximately 30% of wastewater is directly used for crop irrigation of 32,500 ha in Pakistan
- ✓ 26% of the vegetables cultivated in Pakistan are irrigated with untreated wastewater

Wastewater production in Pakistan

Sr. No.	Source	Volume $10^6\ m^3\ y^{-1}$	Percent %	Reference
1	Industry	395	6	NNWC and WWF
2	Commercial	266	5	NNWC and WWF
3	**Urban residential**	**1,628**	**25**	NNWC and WWF
4	**Rural residential**	**3,059**	**48**	NNWC and WWF
5	agriculture	1,036	16	WAPDA 2005
	Total	6,414	100	

A case study for using city wastewater for irrigation

Funded by: Higher Education Commission Pakistan

Duration = 3 years

Amount = 2.5 Million PKR

Use of urban wastewater in Vehari-Pakistan

- ✓ Collected water, soil and plant samples from areas irrigated with untreated city wastewater

Water	Soil	Plant
106	128	156

Heavy metal contents in water of Vehari-Pakistan

Water				
Metals	Mean	Max	Min	S.D
Cd	0.11	0.21	0.01	0.00
Pb	0.16	0.43	0.00	0.21
Cu	0.07	0.48	0.01	0.23
Mn	0.19	0.59	0.01	0.21
Ni	0.07	0.48	0.00	0.23

Heavy metal contents in SOIL of Vehari-Pakistan

0-15 cm				
Cd	1.7	2.4	0.8	0.1
Pb	32	47	18	2
Cu	33	51	13	3
Mn	274	375	129	17
Ni	2.0	3.1	0.8	0.2
15-30 cm				
Cd	1.7	2.4	1.0	0.1
Pb	31	43	21	2
Cu	34	47	19	2
Mn	284	385	178	15
Ni	2.1	2.9	1.0	0.1

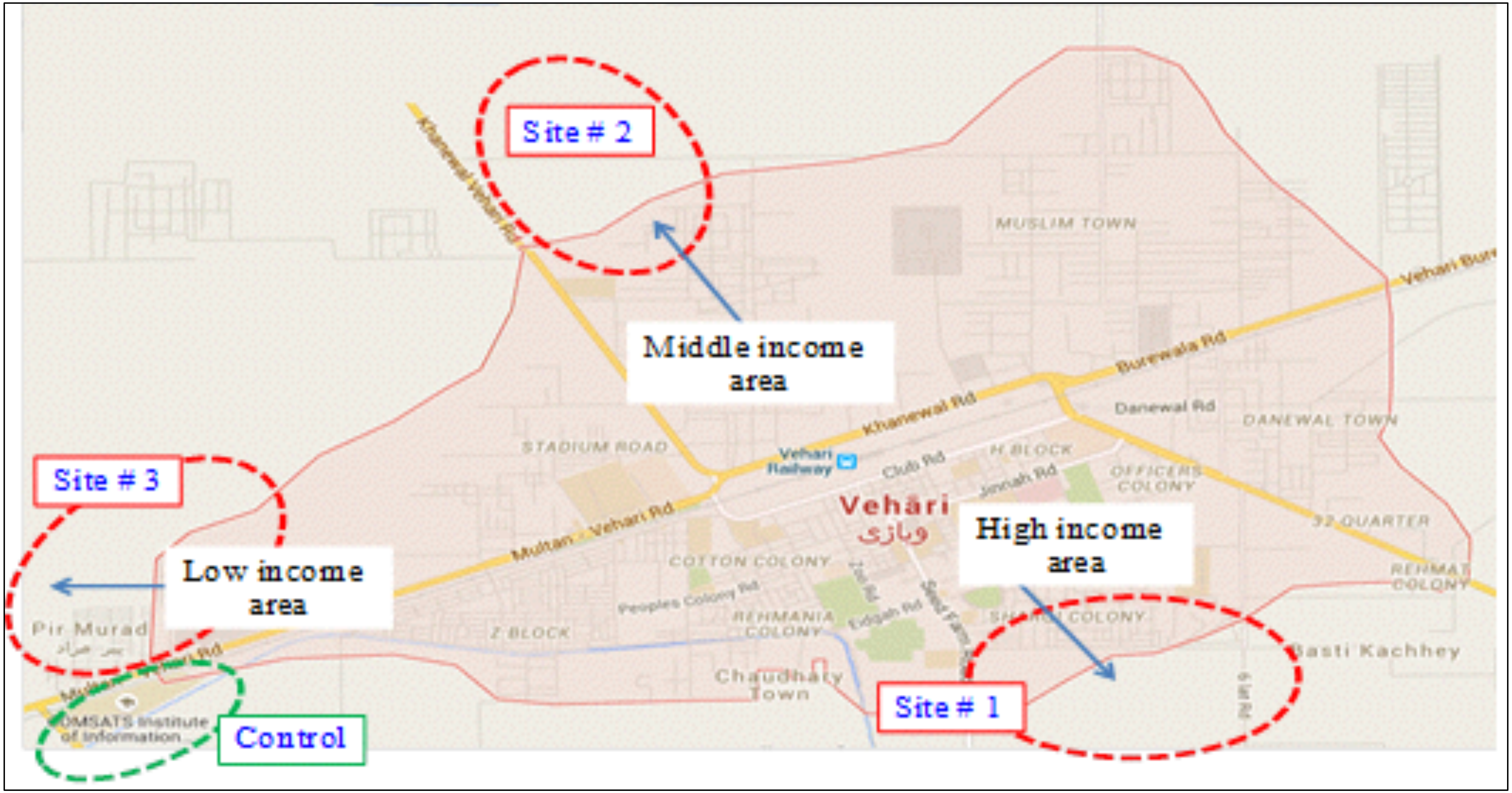
Heavy metal contents in PLANTS of Vehari-Pakistan

PLANTS				
Metals	Mean	Max	Min	S.D
Cd	1.5	2.5	0.6	0.1
Pb	31	40	25	0.9
Cu	3.0	12.3	0.0	0.8
Mn	59	191	9	10
Ni	3.0	12.3	0.0	0.8

A POT Experiment

Influence of wastewater irrigation on heavy metal accumulation in soil and vegetables of Vehari-Pakistan: Environmental consequences and health risk assessment

Influence of groundwater and wastewater irrigation on heavy metal accumulation in soil and vegetables: Environmental consequences and health risk assessment

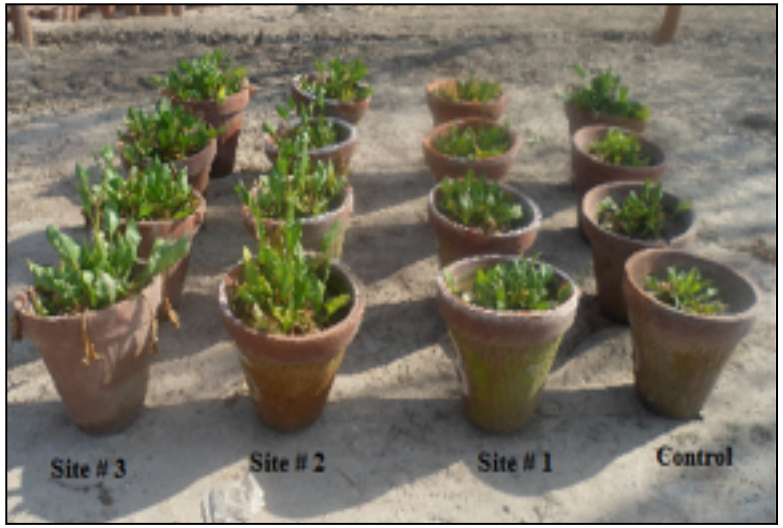


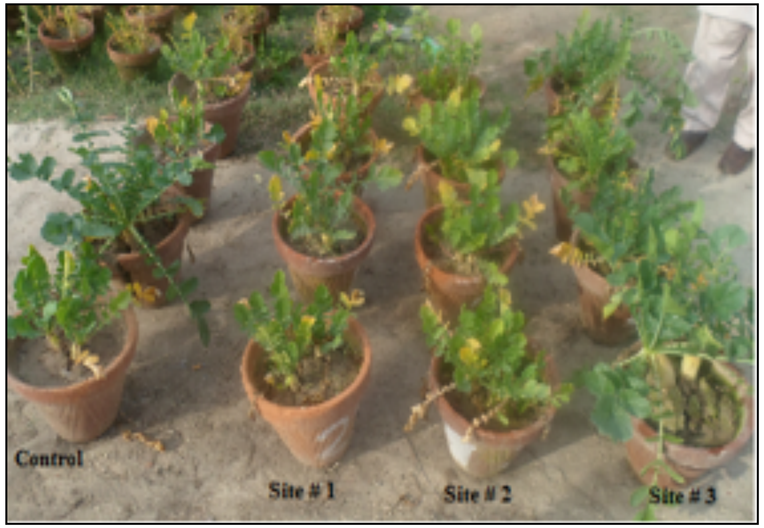
Khalid et al. 2017 Int. J. Phytor

Pot Experiment using wastewater

A pot experiment was conducted at COMSAT Vehari campus.

Sr#	Vegetable	Duration (days)	Wastewater used (L)
1	Radish	80	36
2	Spinach	81	26
3	Cauliflower	120	34





Wastewater analysis

Parameters	Groundwater	Site # 1	Site # 2	Site # 3	Permissible Limits
pH	7.32	6.81	6.72	6.74	6.5-8.5
EC (dS/m)	**0.955**	**1.06**	**2.05**	**3.06**	**0.7-0.3 ds/m**
TSS (mg/l)	9.55	30.5	20.5	20.6	**-**
$HCO3^{2-}$ (me L-)	4.10	**16.45**	**12.57**	**11.48**	**1.5-8.5 me/l**
Cl^- (me L-)	4.50	8.50	6.18	6.00	4-10 me /l
Ca^{2+} + Mg^{2+} (me L-)	6.29	**11.37**	**10.60**	**10.48**	**>10**
SAR ($mmolL^{-1}$)1/2	**1.84**	**6.77**	**4.30**	**4.42**	**0.7-0.2**
Pb (mg/L)	0.31	0.26	0.25	0.18	0.5 mg/L

Health Risk Assessment

Vegetables	Treatment	Risk assessment parameters		
		EDI	HRI	MDI
Spinach	Control	0.0016	0.45	23.6
	Site 1	0.0025	0.70	19.9
	Site2	0.0027	0.75	17.1
	Site 3	0.0030	0.85	13.0
Radish	Control	0.0066	**1.84**	10.3
	Site 1	0.0083	**2.32**	8.4
	Site2	0.0078	**2.18**	8.7
	Site 3	0.0054	**1.52**	8.1
Cauliflower	Control	0.0042	**1.16**	16.7
	Site 1	0.0045	**1.27**	14.4
	Site2	0.0053	**1.47**	14.6
	Site 3	0.0062	**1.75**	11.6

EDI; estimated daily intake, HRI; Health risk index, MDI; Maximum allowable daily vegetable intake

Wastewater irrigation: Risky or safe

Risk associated with the use of heavy metal contaminated vegetables as a result of wastewater irrigation depends on

<u>Vegetable type</u>

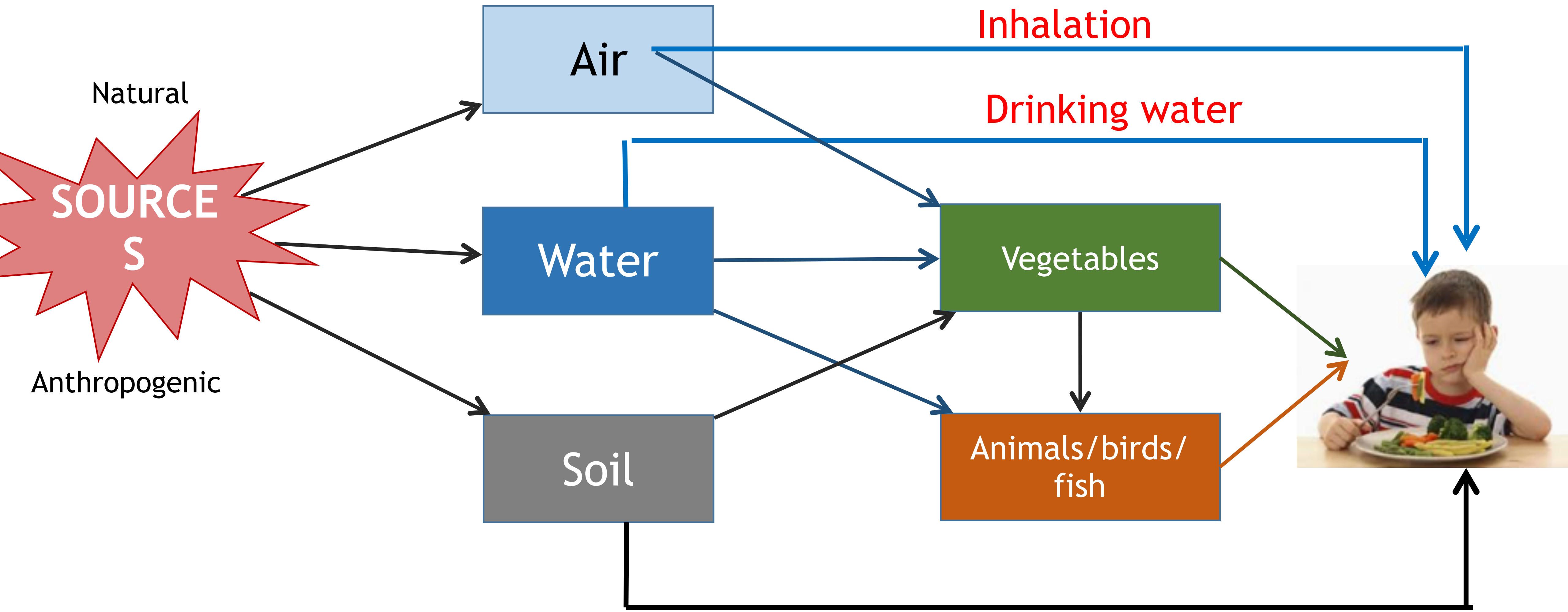
<u>Mix use of vegetables</u> can reduce heath risks associated with the use of heavy metal contaminated vegetables

La gestion de l’arsenic dans les écosystèmes et la chaîne alimentaire

Why Arsenic

- Arsenic: The most toxic element (Type A carcinogenic)
- Found in > 200 natural minerals
- Omnipresent in ecosystem

Possible pathways of arsenic build-up in humans?

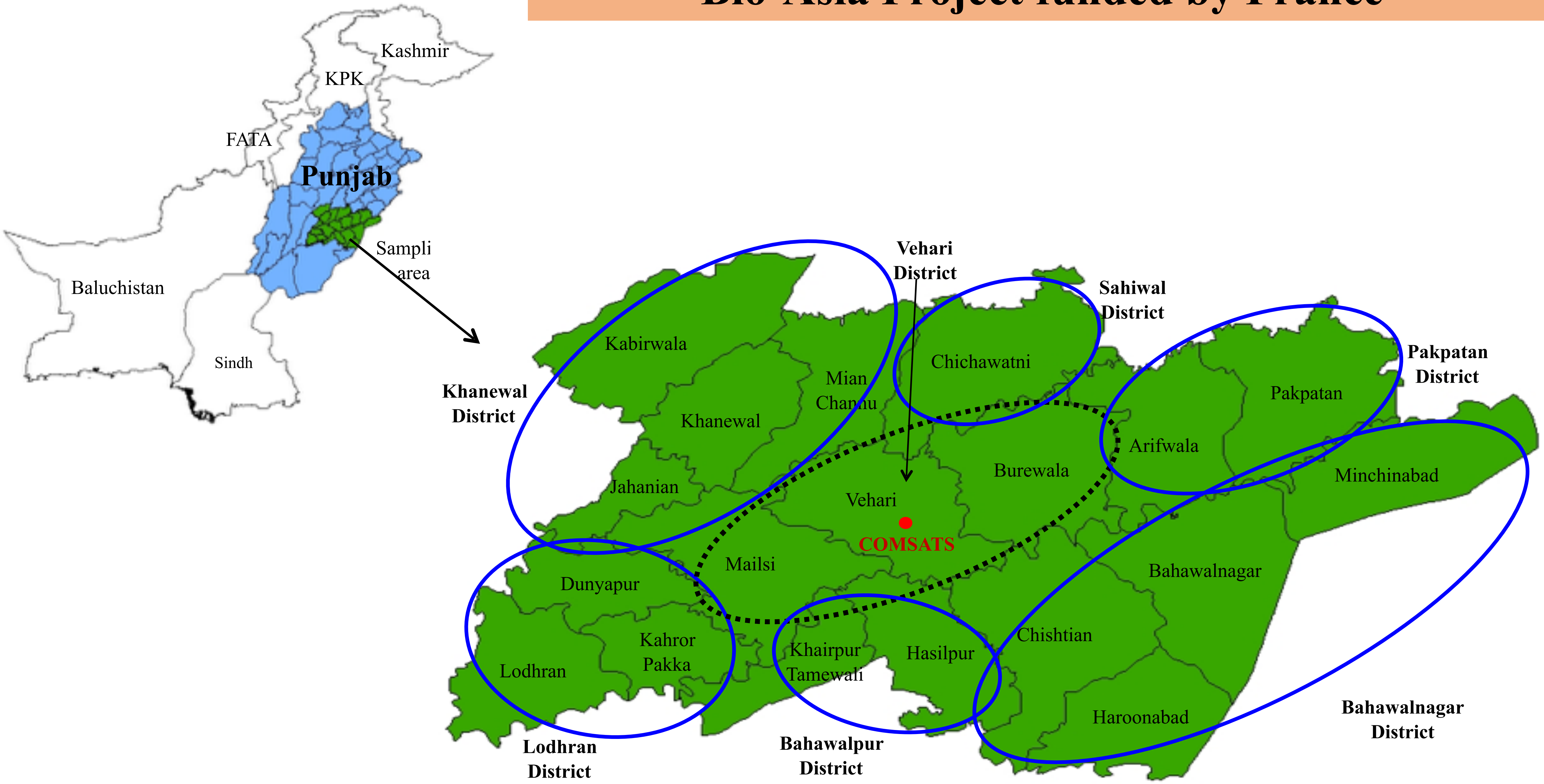


Abbas et al. 2018 Int. J. Environ. Res. Public Health

Metal contents generally build-up in tissues from left to right

Arsenic build-up in humans via drinking water in Pakistan

Bio-Asia Project funded by France



Ground/Drinking water analysis of Vehari district used for drinking purpose

RISK ASSESMENT & REMDIATION

90% of Vehari population uses groundwater for drinking purpose
without any treatment

Khalid et al. 2018 Exposure & Healt

Groundwater Analysis of Vehari District (156 Samples)

Study area	Rural	Urban	Total
Burewala Tehsil	41	9	50
Mailsi Tehsil	23	16	39
Vehari Tehsil	56	11	67
Vehari District	**120**	**36**	**156**



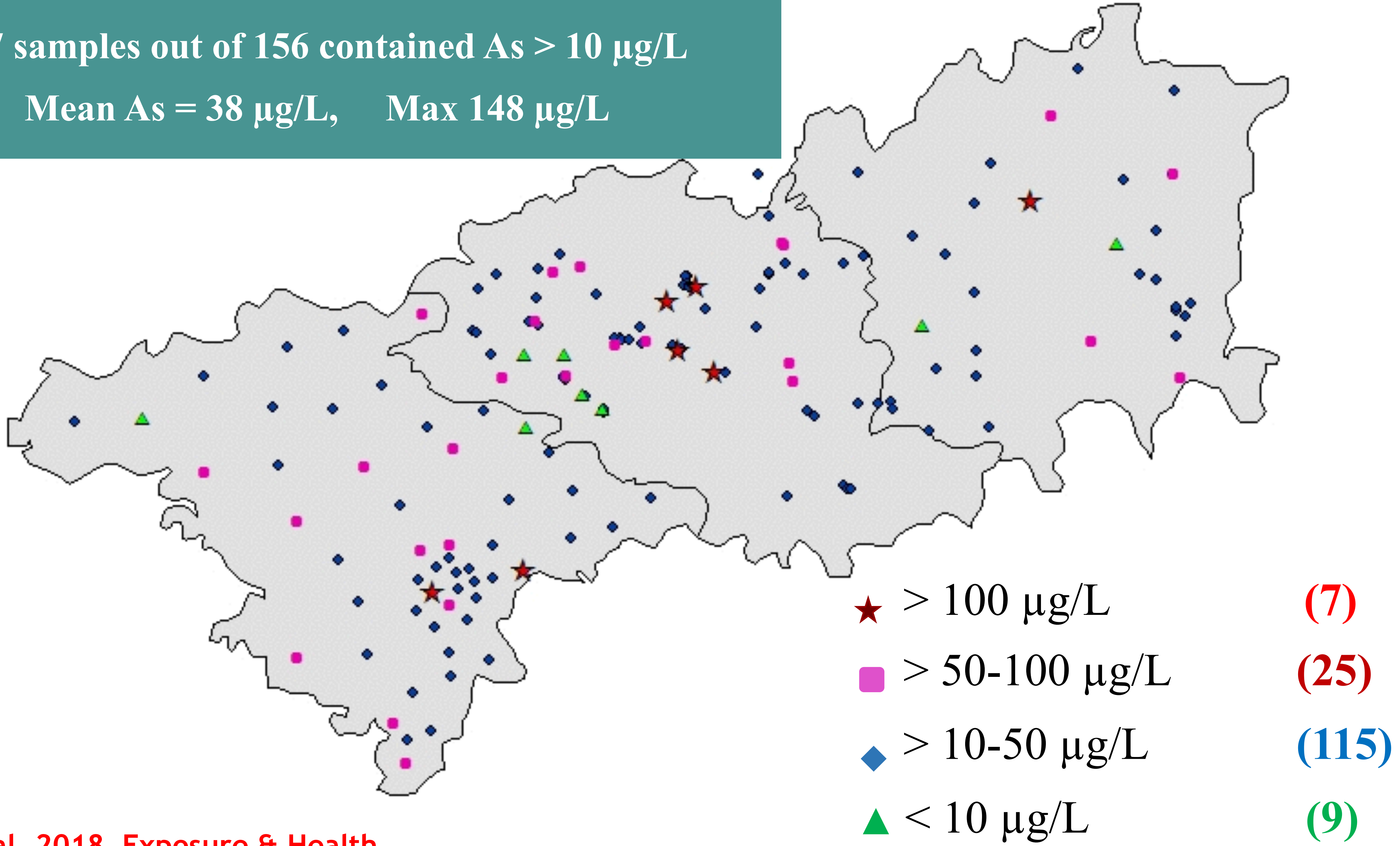


Physico-chemical analysis (Drinking Purpose)

Parameters	**Mean**	**WHO Guideline**
pH	7.8	6.5-8.5
EC (µS/cm)	1207	2000 µS/cm
TDS (mg/l)	**879**	**500 mg/l**
Hardness (mg/l)	316	500 mg/l
Na (ppm)	119	200 mg/l
K (ppm)	9.7	200 mg/l
Ca (ppm)	57	200 mg/l
CO_3^- ($mmol_c$/L)	98	
HCO_3^- ($mmol_c$/L)	27	
Cl^{-1} ($mmol_{c/}$L)	21	250 mg/l
$Ca^{+2} + Mg^{+2}$	110	

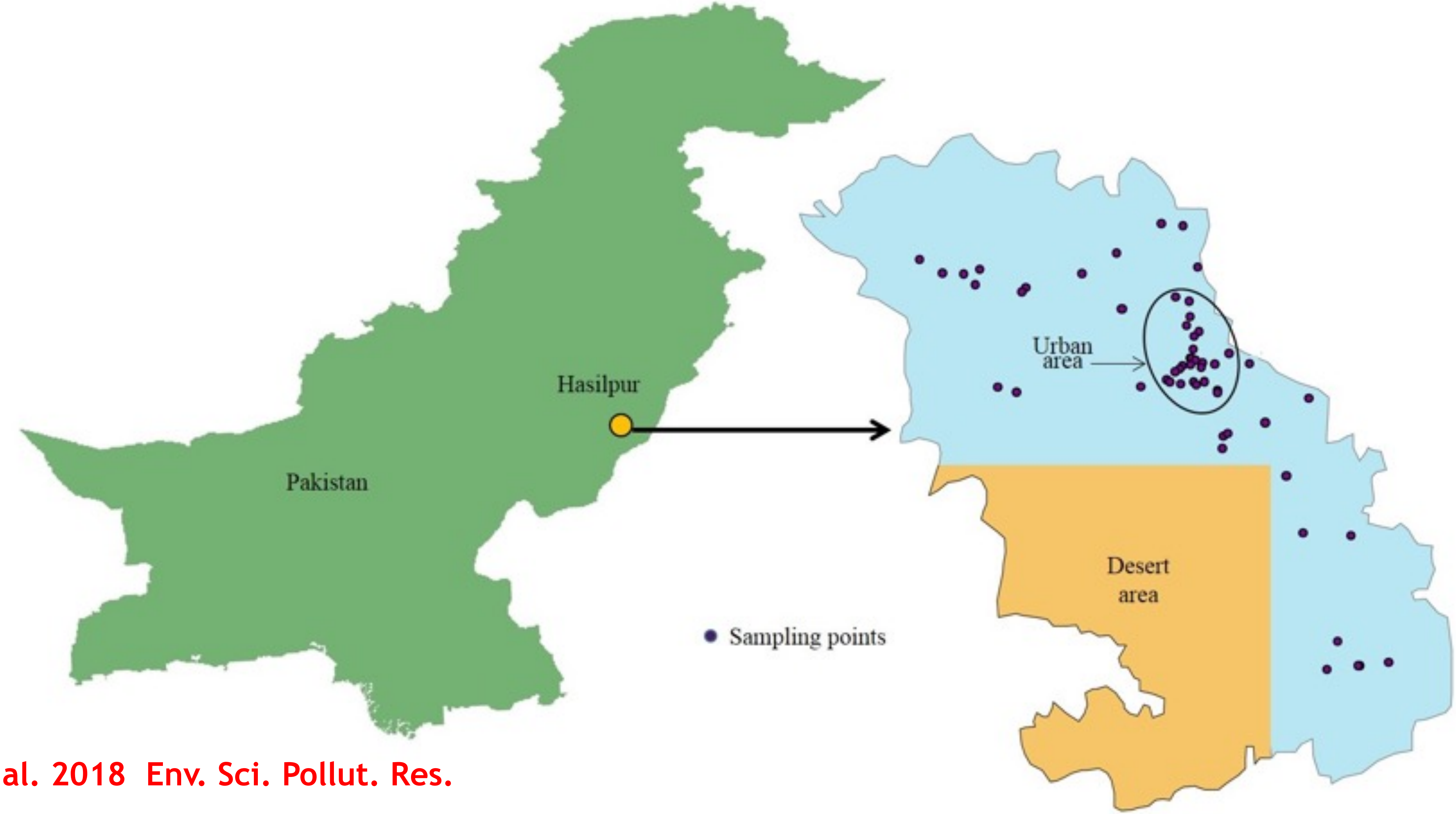
147 samples out of 156 contained As > 10 µg/L

Mean As = 38 µg/L,   Max 148 µg/L



Khalid et al. 2018 Exposure & Health

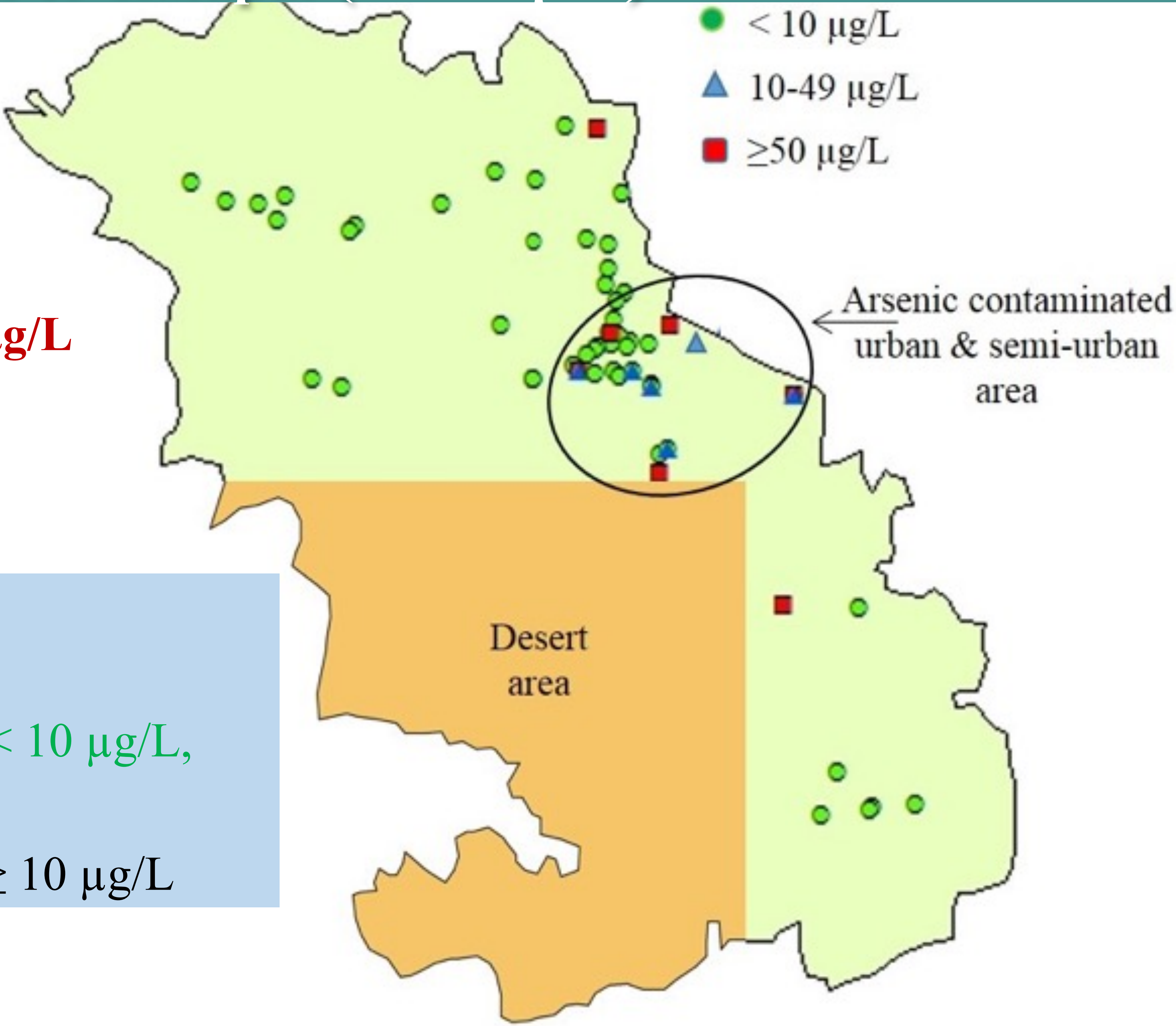
Groundwater Arsenic Analysis of Hasilpur (61 Samples)



Tabassum et al. 2018 Env. Sci. Pollut. Res.

Groundwater Arsenic Analysis of Hasilpur (61 Samples)

Mean value of As in Hasilpur = **9 µg/L**



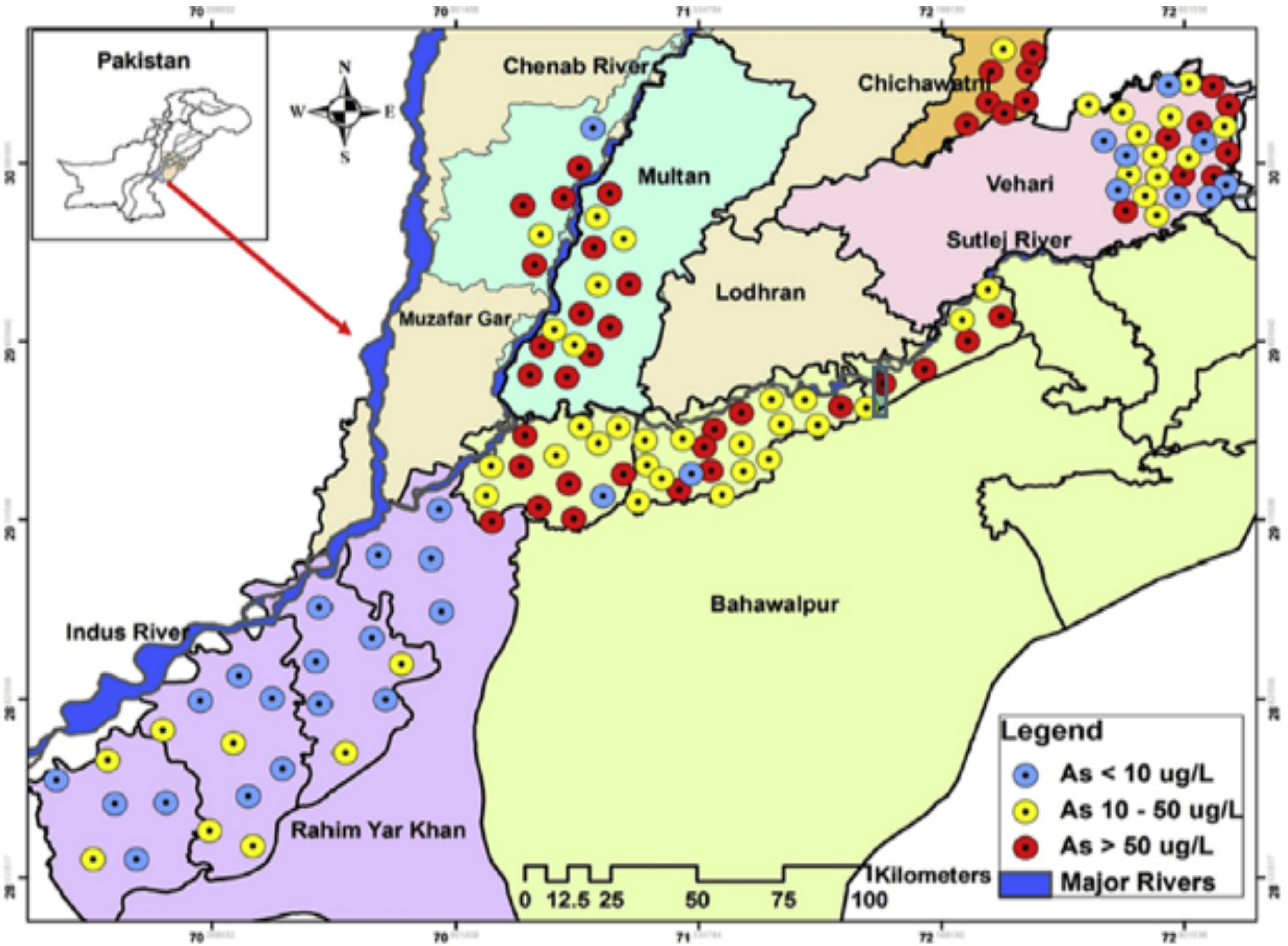
Out of 61 groundwater samples,

48 samples (79%) have As contents < 10 µg/L,

13 samples (21%) with As contents ≥ 10 µg/L

Arsenic level & speciation in aquifers of Punjab-Pakistan

1. Chichawatni
2. Vehari
3. Rahim Yar Khan
4. Bahawalpu
5. Multan



Shakoor et al. 2018 Chemosphere

Arsenic level & speciation in aquifers of Punjab-Pakistan

Table 2
Percentage (%) distribution of arsenic (As) species in selected groundwater samples from five rural areas of Punjab, Pakistan.

	Total number of groundwater samplesa ($n = 29$)	CW ($n = 6$)	Vh ($n = 4$)	RYK ($n = 3$)	BP ($n = 9$)	Multan ($n = 7$)
	(%)					
Arsenite (As(III))						
Mean	25	39	15	38	3	39
Median	19	43	9	34	0	20
Minimum	0	29	0	13	0	0
Maximum	80	55	43	67	21	80
SD (±)	25	9	20	27	7	32
Arsenate (As(V))						
Mean	74	58	85	62	97	58
Median	81	57	92	66	100	80
Minimum	20	45	57	33	79	20
Maximum	100	71	100	87	100	100
SD (±)	27	10	20	27	7	35

SD: Standard deviation; CW: Chichawatni; Vh: Vehari; RYK: Rahim Yar Khan; BP: Bahawalpur.

Use of agri waste products for As removal from water

Use of agri waste products for As removal from water

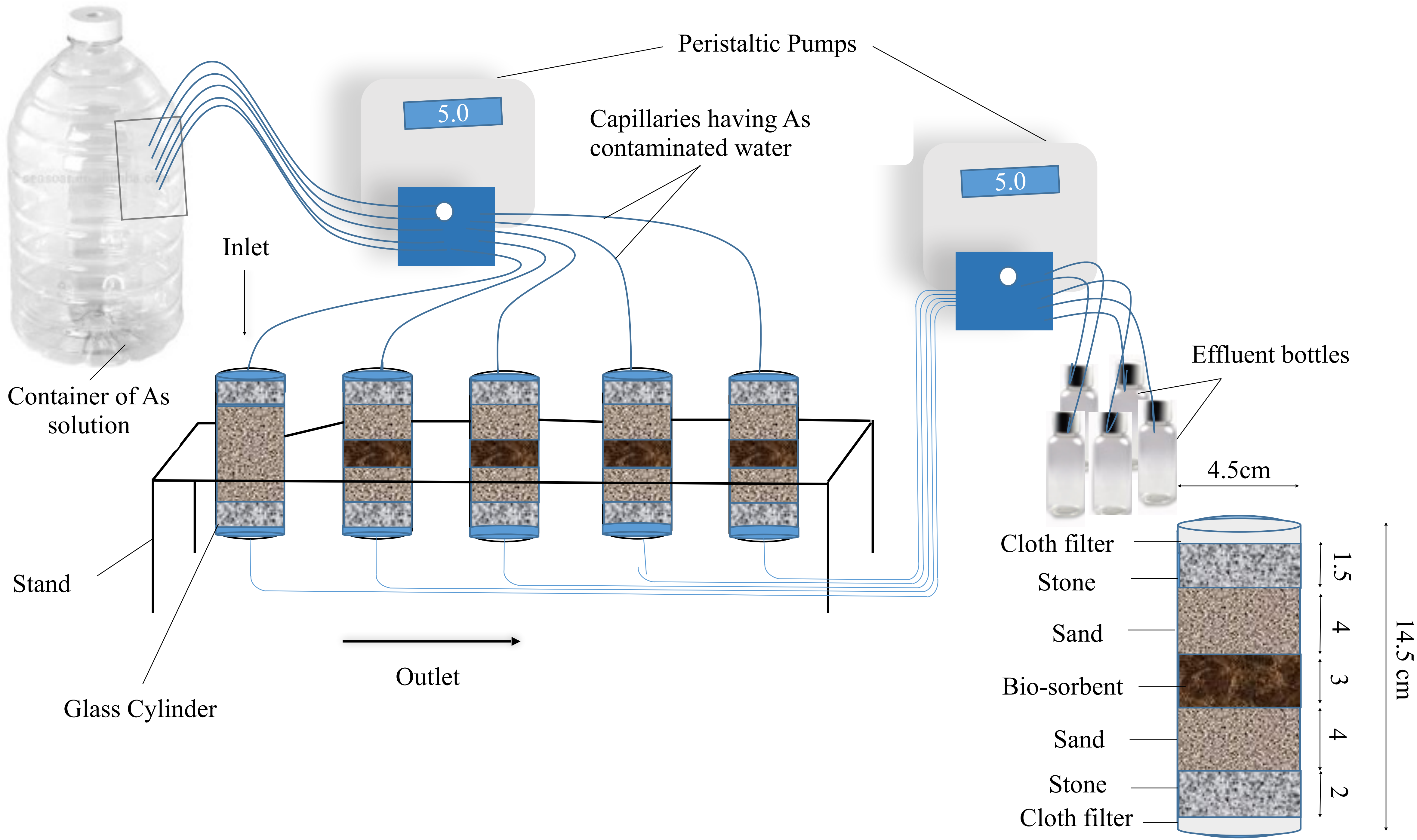
✓Three samples from groundwater (5, 10 & 50 ppb arsenic)

✓Three samples of known As level prepared in Lab (10, 50 & 100 ppb arsenic)

We used four agricultural byproducts as adsorbent : *Banana peels, orange peels, rice husk and biochar*






Peristaltic Pumps
5.0
5.0
Capillaries having As contaminated water
Inlet
Container of As solution
Effluent bottles
4.5cm
Stand
Glass Cylinder
Outlet
Cloth filter
Stone
Sand
Bio-sorbent
Sand
Stone
Cloth filter
1.5
4
3
4
2
14.5 cm

Analysis of As contaminated water after treatment (2nd Study)

Time	GW-1 (5 µg/L)		GW-2 (10 µg/L)		GW-3 (50 µg/L)	
1 h	Sand	0	Sand	0	Sand	10
	Orange	0	Orange	0	Orange	5
	Banana	0	Banana	0	Banana	5
	Rice Husk	0	Rice Husk	0	Rice Husk	5
	Biocahar	0	Biocahar	0	Biocahar	5
2 h	Sand	0	Sand	0	Sand	0
	Orange	0	Orange	0	Orange	0
	Banana	0	Banana	0	Banana	0
	Rice Husk	0	Rice Husk	0	Rice Husk	0
	Biocahar	0	Biochar	0	Biocahar	0
3 h	Sand	0	Sand	0	Sand	0
	Orange	0	Orange	0	Orange	0
	Banana	0	Banana	0	Banana	0
	Rice Husk	0	Rice Husk	0	Rice Husk	0
	Biocahar	0	Biochar	0	Biochar	0
4h	Sand	0	Sand	0	Sand	0
	Orange	0	Orange	0	Orange	0
	Banana	0	Banana	0	Banana	0
	Rice Husk	0	Rice Husk	0	Rice Husk	0
	Biocahar	0	Biocahar	0	Biochar	0

Analysis of known As contaminated water after treatment (2nd Study)

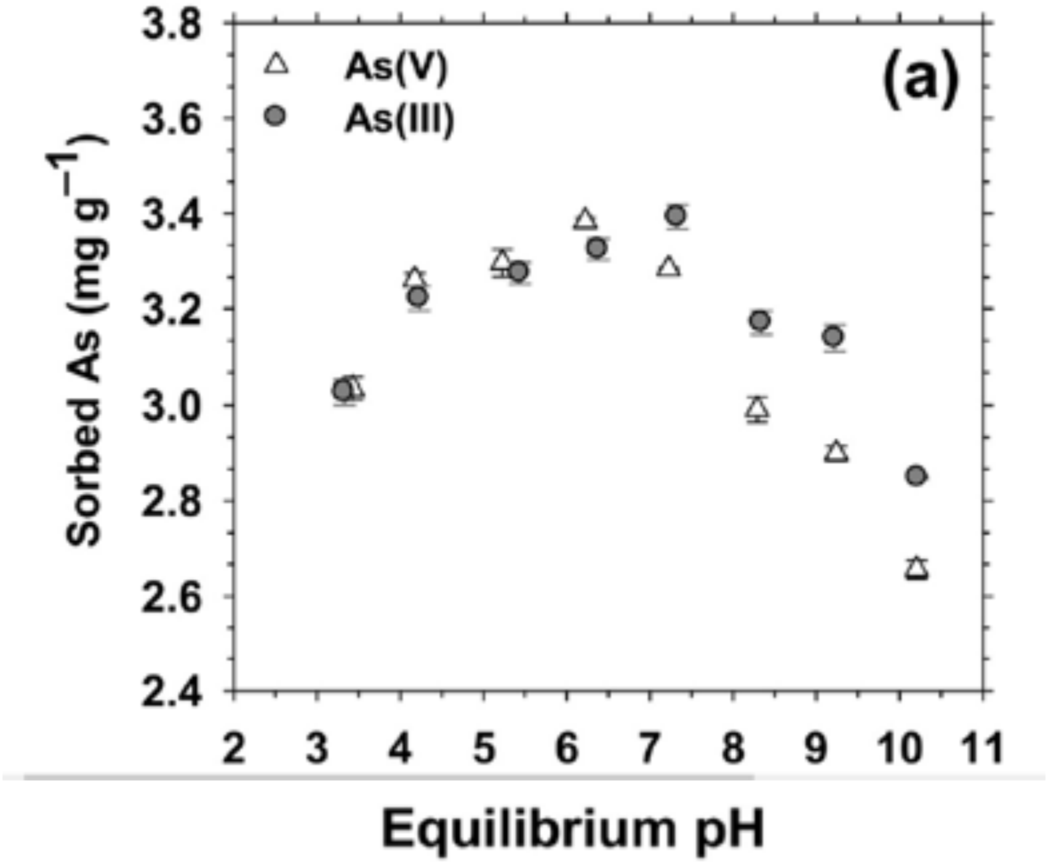
Time	10 µg/L		50 µg/L		100 µg/L	
1 h	Sand	5	Sand	10	Sand	50
	Orange	5	Orange	5	Orange	10
	Banana	5	Banana	5	Banana	10
	Rice Husk	5	Rice Husk	10	Rice Husk	10
	Biocahar	5	Biocahar	5	Biocahar	10
2 h	Sand	0	Sand	0	Sand	5
	Orange	0	Orange	0	Orange	5
	Banana	0	Banana	0	Banana	5
	Rice Husk	0	Rice Husk	0	Rice Husk	5
	Biocahar	0	Biocahar	0	Biocahar	5
3 h	Sand	0	Sand	0	Sand	0
	Orange	0	Orange	0	Orange	0
	Banana	0	Banana	0	Banana	0
	Rice Husk	0	Rice Husk	0	Rice Husk	0
	Biocahar	0	Biocahar	0	Biocahar	0
4h	Sand	0	Sand	0	Sand	0
	Orange	0	Orange	0	Orange	0
	Banana	0	Banana	0	Banana	0
	Rice Husk	0	Rice Husk	0	Rice Husk	0
	Biocahar	0	Biocahar	0	Biocahar	0

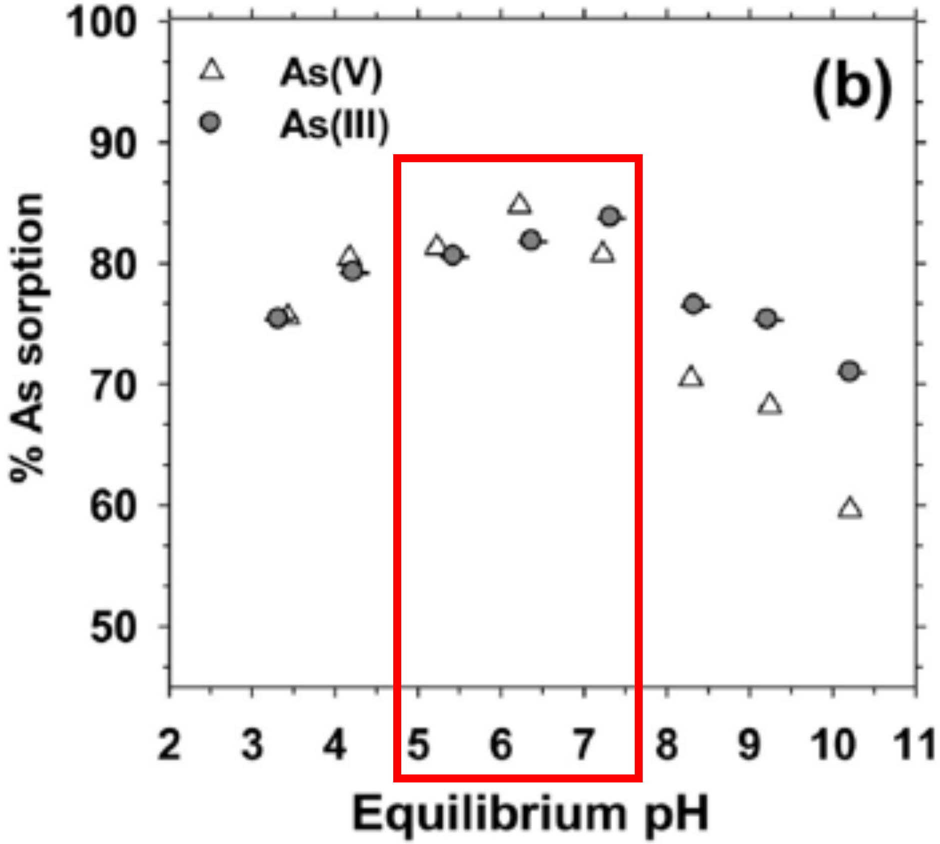
Arsenic removal by Japanese oak wood biochar in aqueous solutions and well water: Investigating arsenic fate using integrated spectroscopic and microscopic techniques

Japanese oak wood biochar

Niazi et al. 2018 Sci Total Enviro

Arsenic removal by Japanese oak wood biochar





Effect of equilibrium pH on (a) sorption capacity (mg g−1) of arsenite (As(III)) and arsenate (As(V)) by Japanese oak wood-derived biochar prepared at 500 °C (OW-BC); (b) removal percentage (%) of As(III) and As(V) by OW-BC (data are presented as mean ± standard error (n=3)).

Arsenic removal by Japanese oak wood biochar

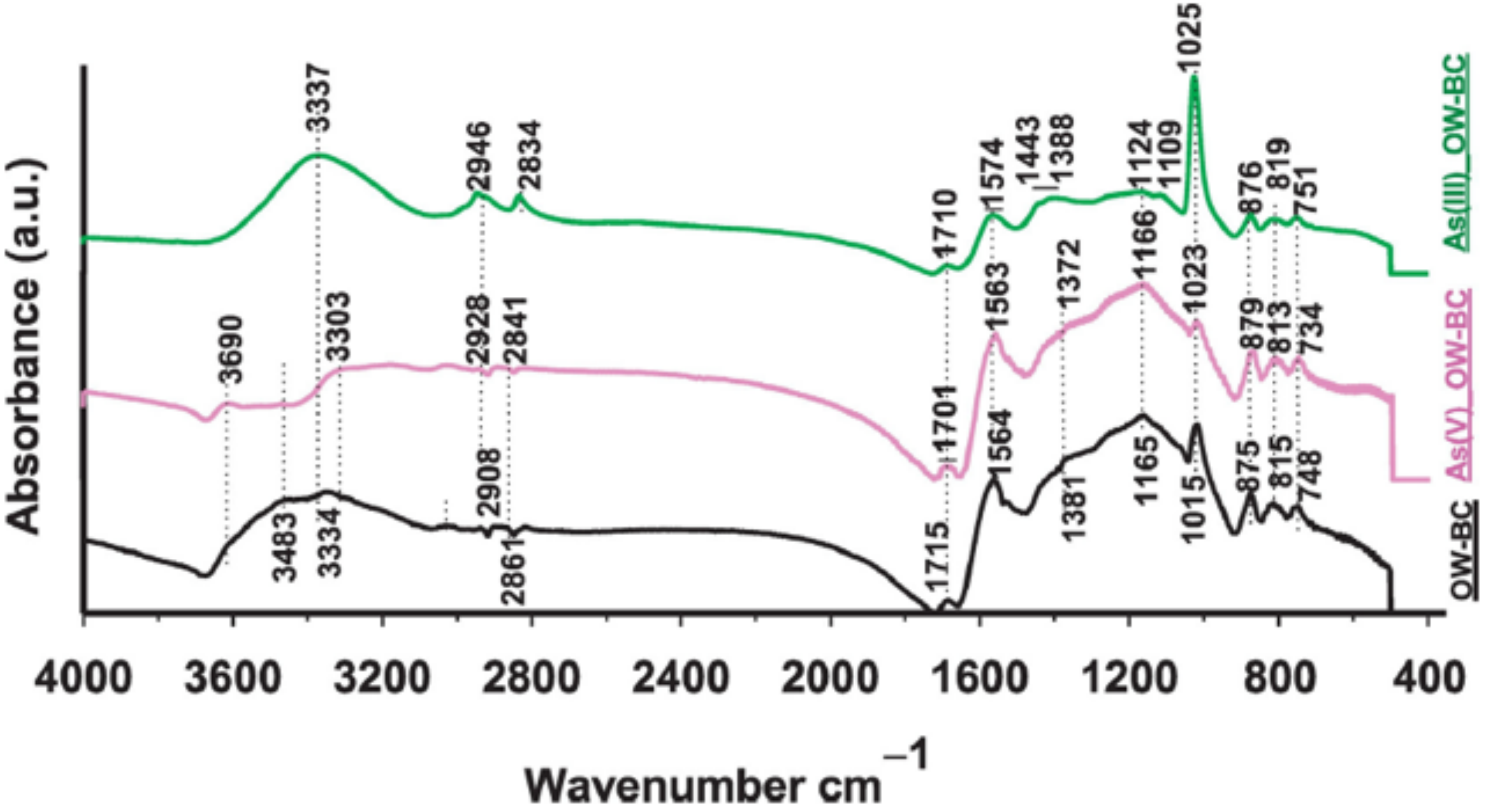


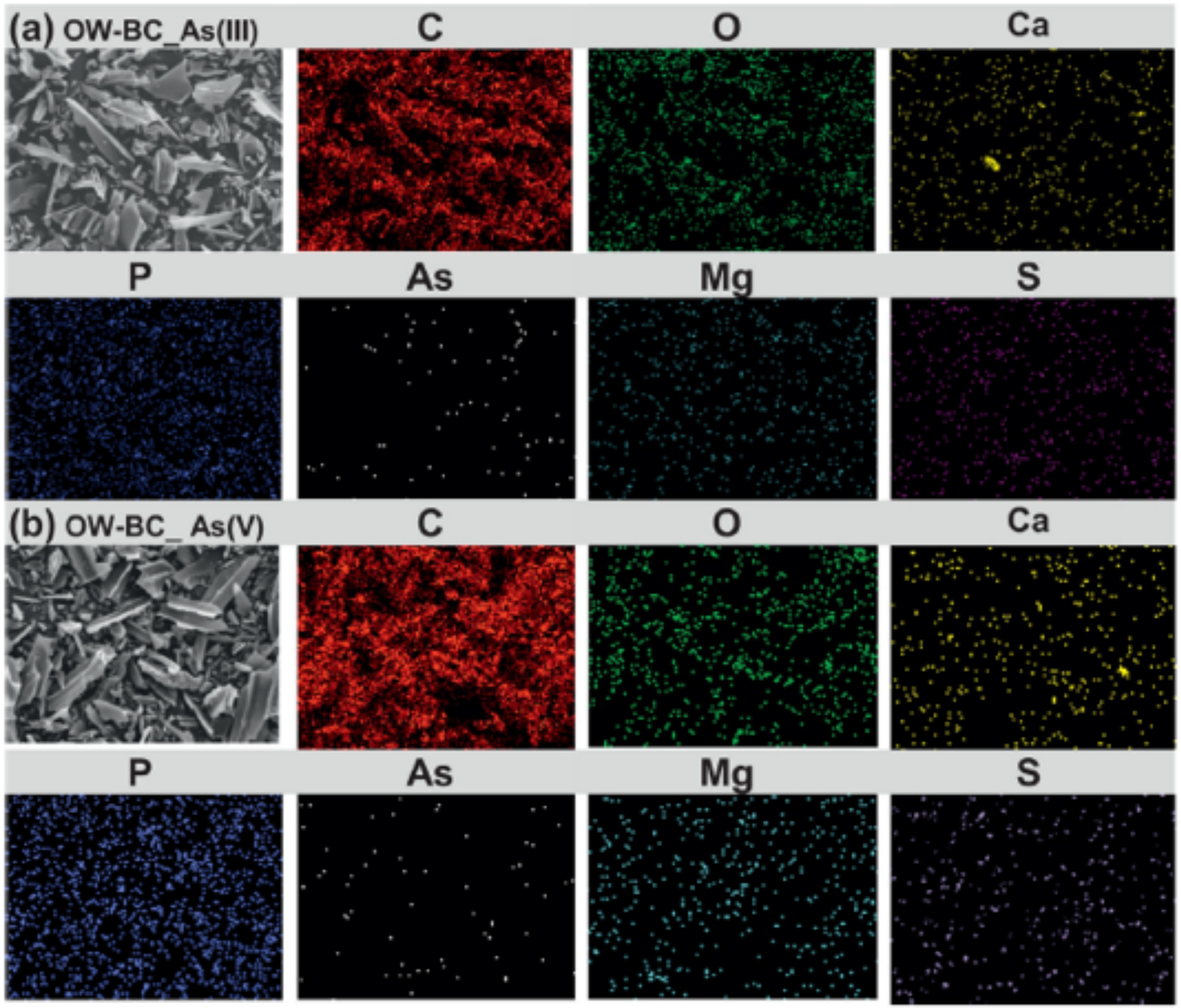
Fig. 2. The FTIR absorbance spectra of Japanese oak wood-derived biochar prepared at 500 °C (OW-BC); solid black line (—) shows OW-BC_As-unloaded, solid pink line (—) shows OW-BC_As(V)-loaded, solid green line (—) shows OW-BC_As(III)-loaded spectra.

Arsenic removal by Japanese oak wood biochar

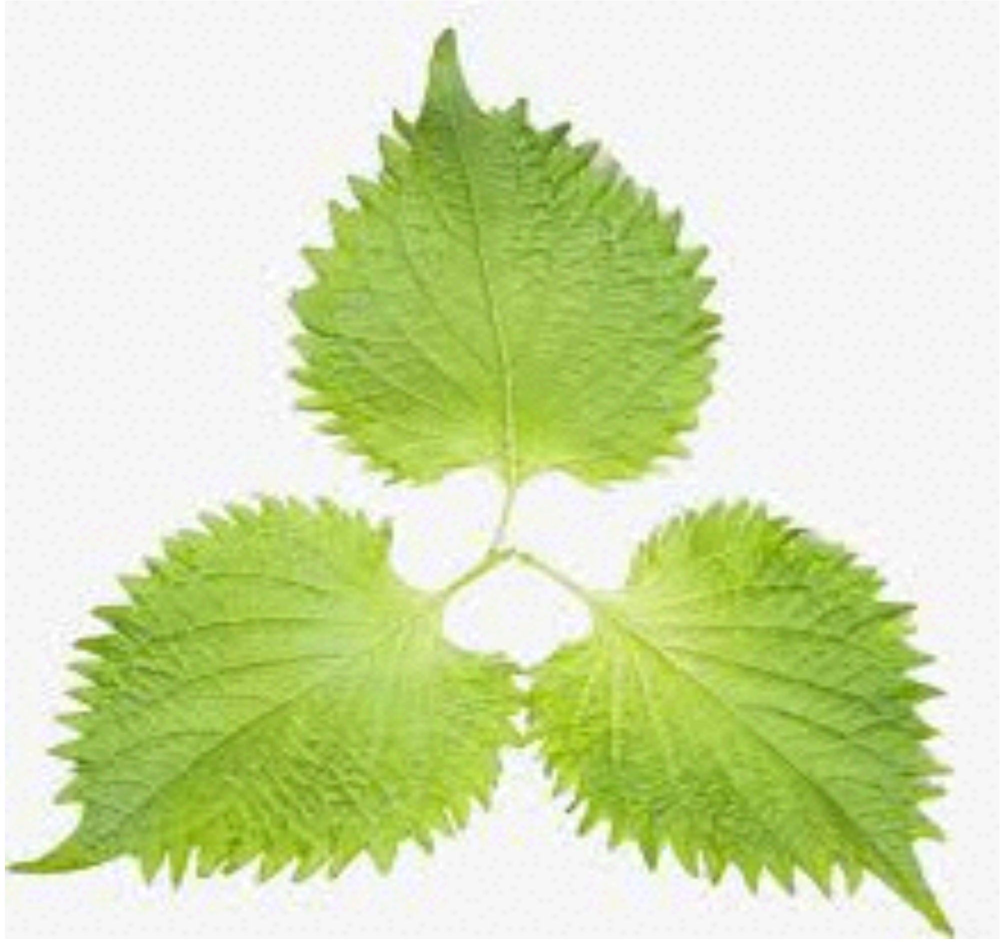
Scanning electronmicroscope (SEM) images and the energy dispersive X-ray spectroscopy (EDX) elemental dotmaps of As(III)- and As(V)-loaded Japanese oak wood-derived biochar prepared at 500 °C (OW-BC):

(a)OW-BC-As(III), and (b)OW-BC-As(V).

Elemental dotmaps of C (red), O (green), Ca (yellow), P (blue), As (white),Mg (sky-blue) and S (purple) are shown of representative As loaded OW-BC.



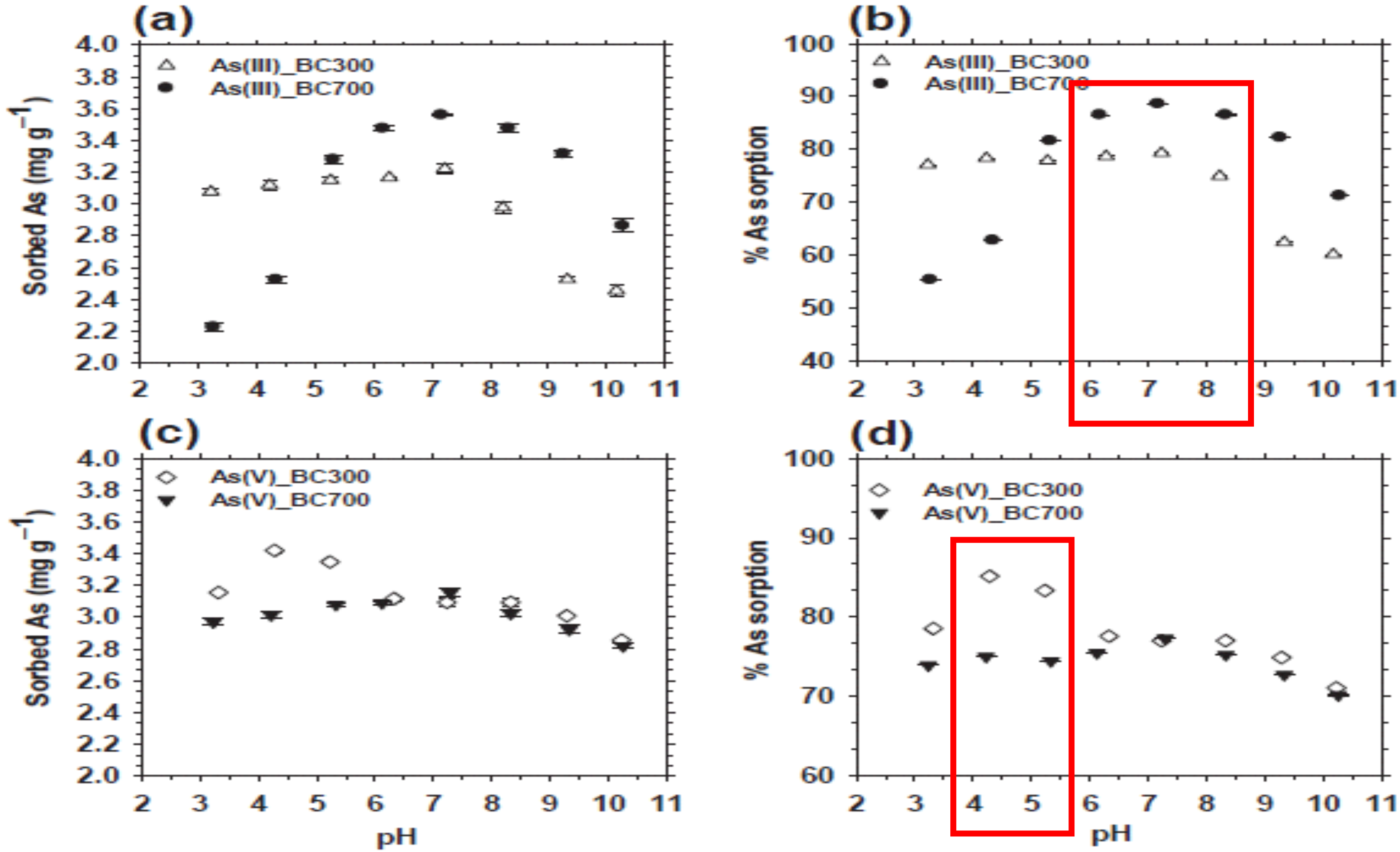
Arsenic removal by perilla leaf biochar in aqueous solutions and groundwater: An integrated spectroscopic and microscopic examination



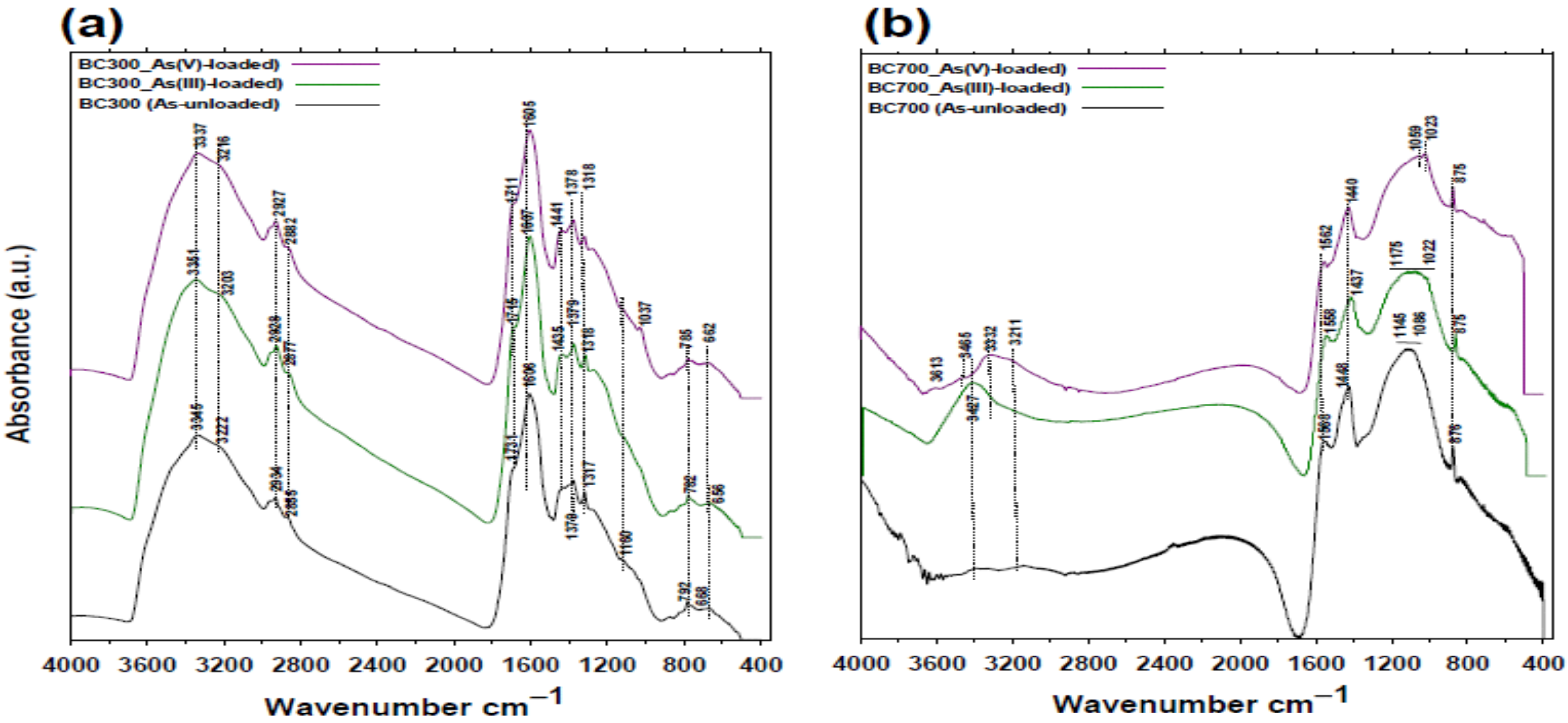
Perilla leaf biochar

Niazi et al. 2018 Environmental Pollut

Arsenic removal by perilla leaf biochar in aqueous solutions and groundwater: An integrated spectroscopic and microscopic examination

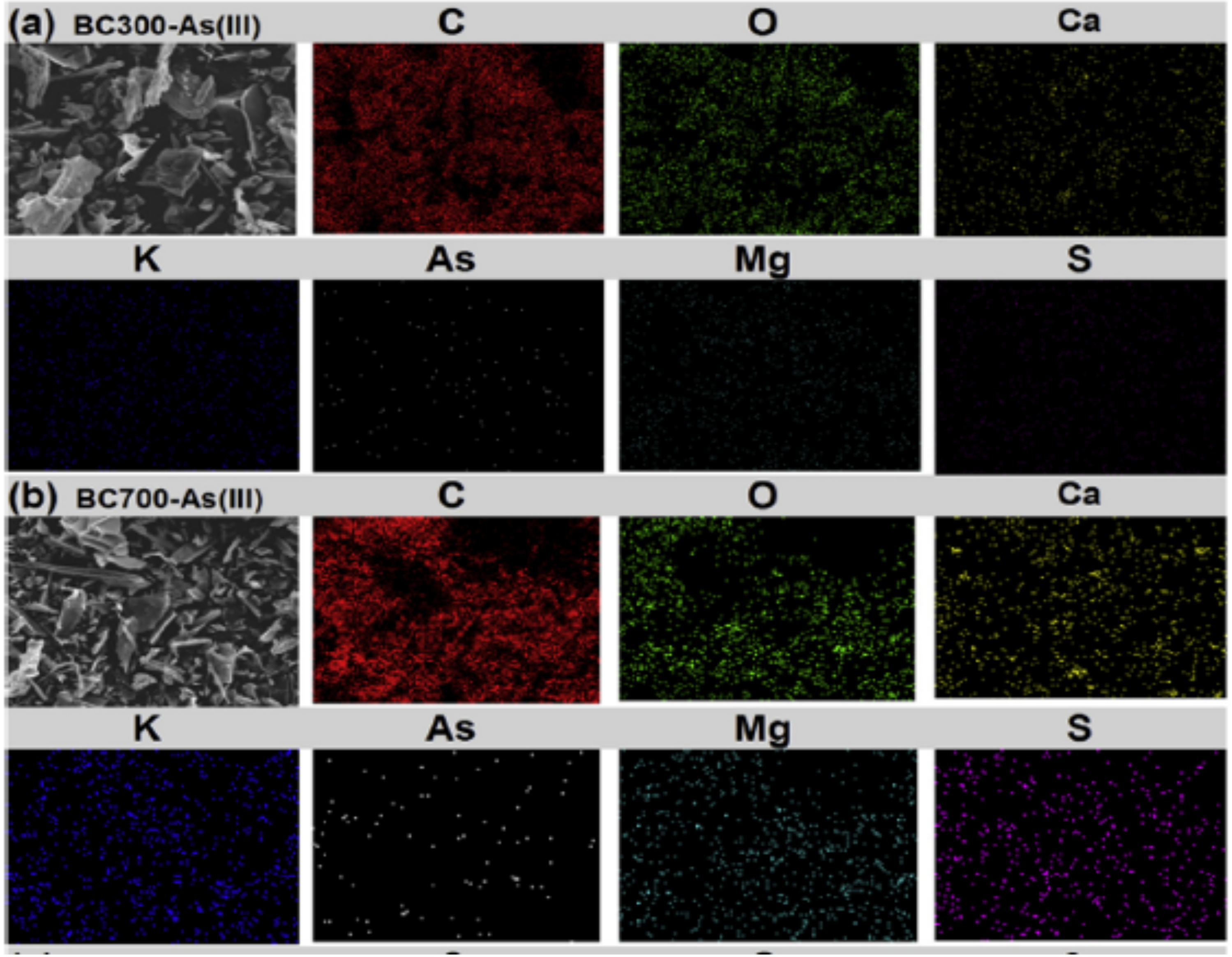


Arsenic removal by perilla leaf biochar in aqueous solutions and groundwater: An integrated spectroscopic and microscopic examination



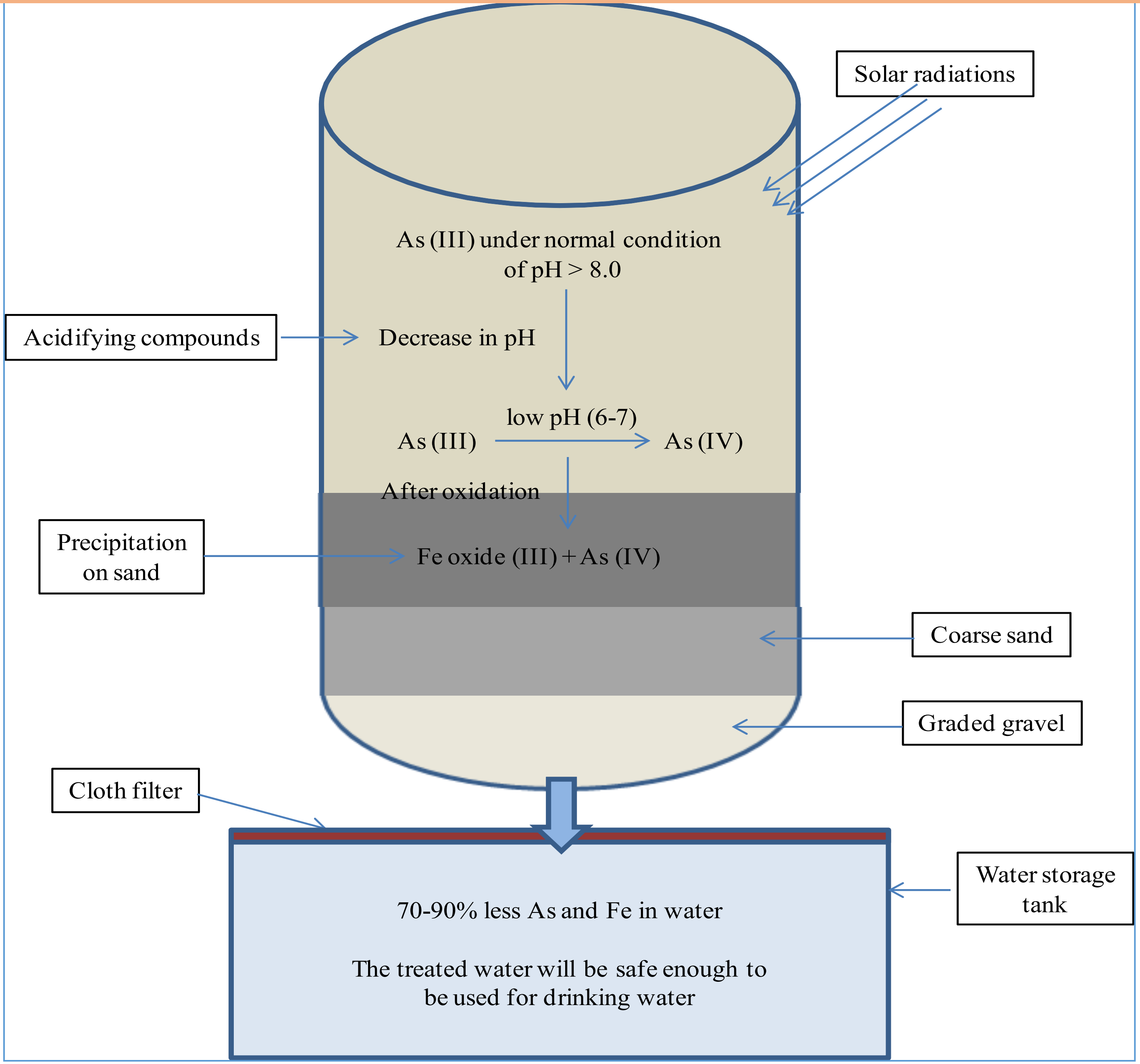
Arsenic removal by perilla leaf biochar in aqueous solutions and groundwater: An integrated spectroscopic and microscopic examination

Scanning electron microscope (SEM) images and the energy dispersive X-ray spectroscopy (EDX) elemental dot maps of As(III)- and As(V)-loaded perilla leaf-derived biochars prepared at 300 C (BC300) and 700 C (BC700).



Arsenic removal unit

Use of agri and industrial waste products to co-precipitates Fe and As from drinking water



THANKS MERCI