Figure

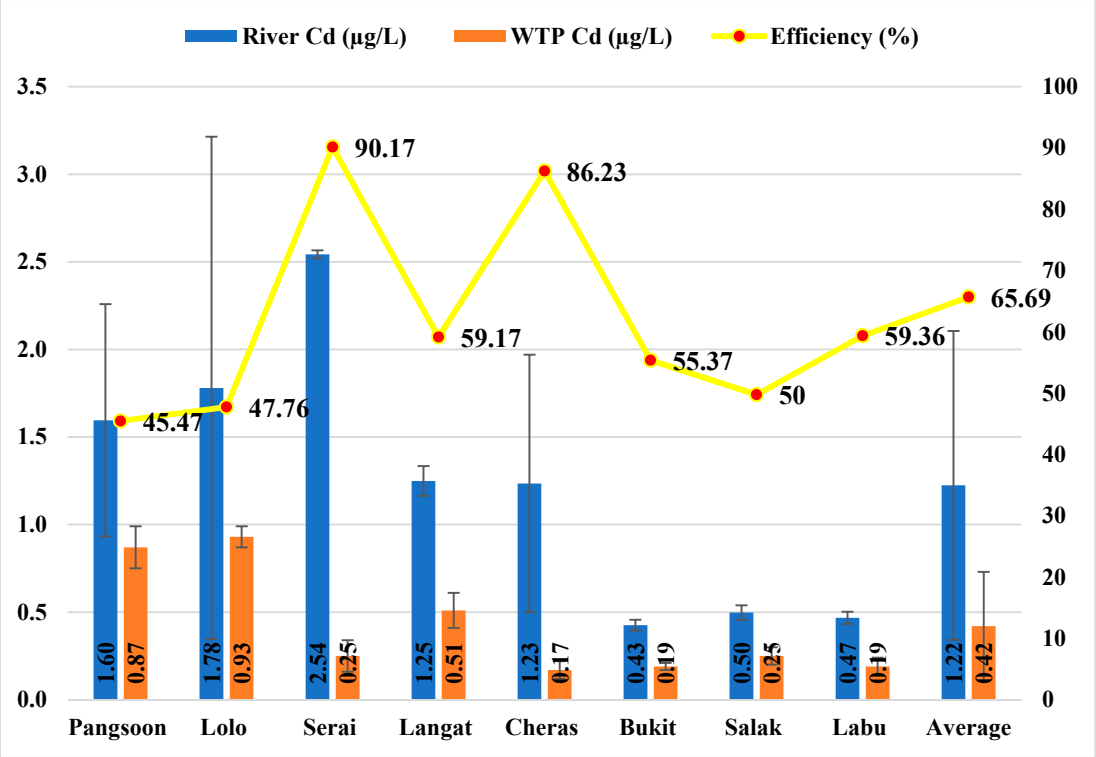

Figure S1. Cd (µg/L) Concentration Removal Efficiency (%) by the Water Treatment Plants (WTPs) in the Langat River Basin, Malaysia.

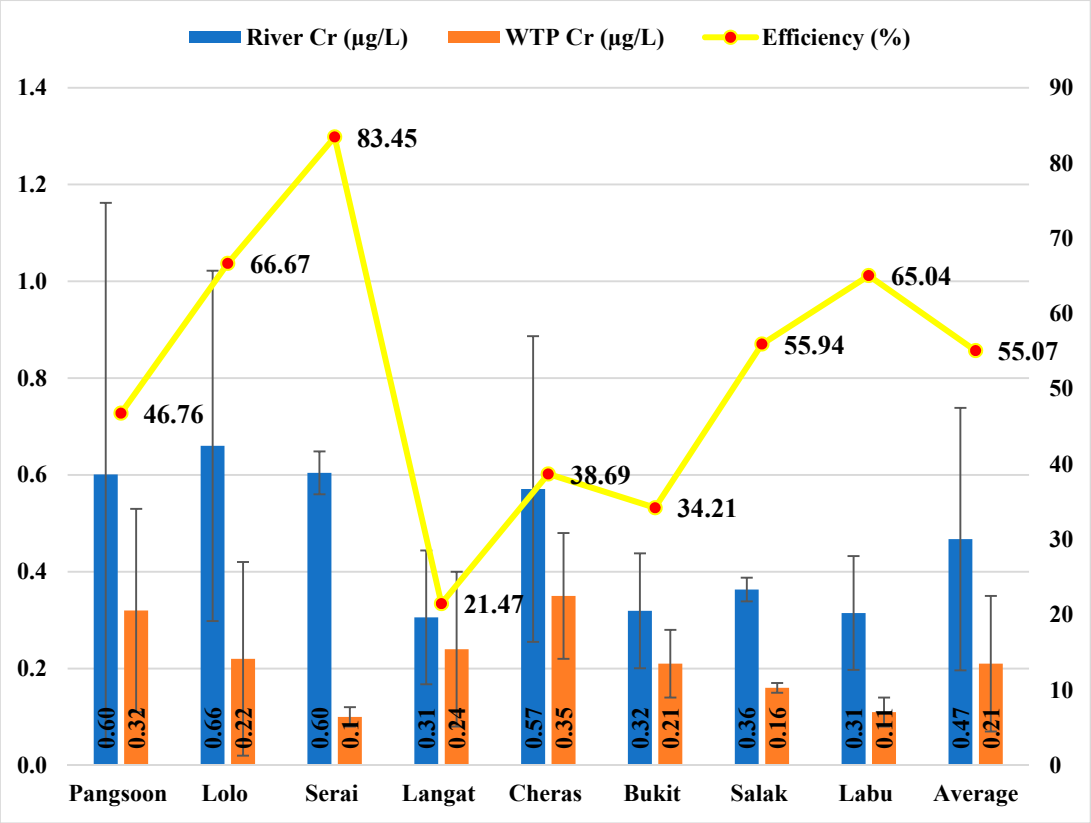

Figure S2. Cr (µg/L) Concentration Removal Efficiency (%) by the Water Treatment Plants (WTPs) in the Langat River Basin, Malaysia.

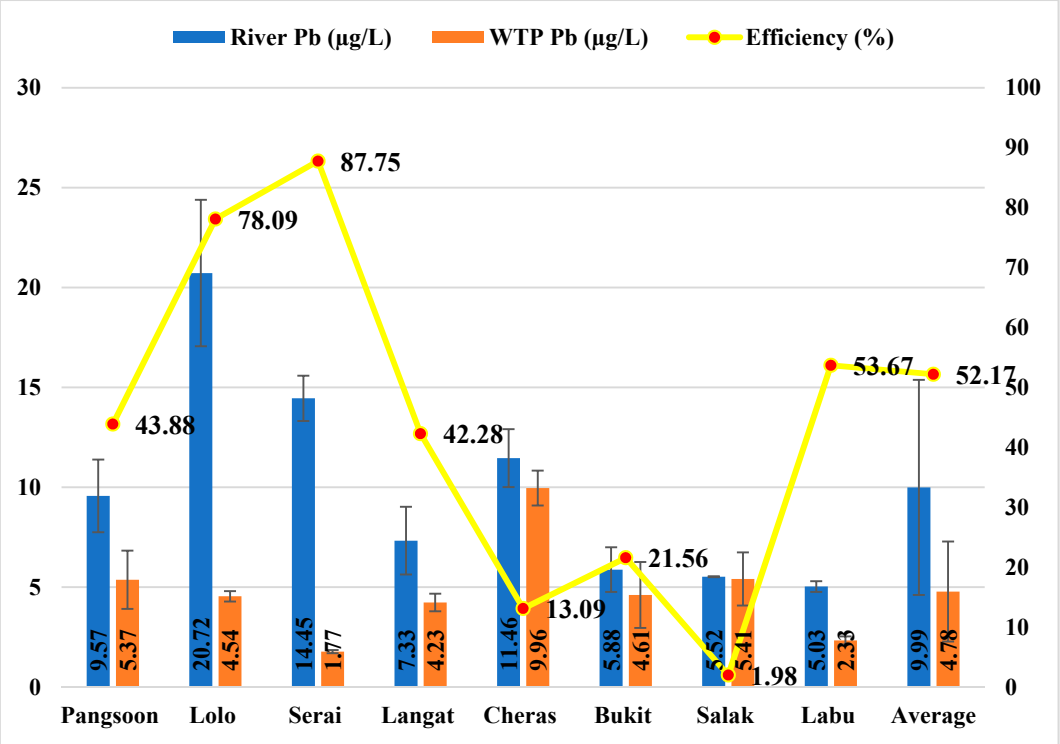

Figure S3. Pb (µg/L) Concentration Removal Efficiency (%) by the Water Treatment Plants (WTPs) in the Langat River Basin, Malaysia.

Table

Table S1. Malaysian standards of physio-chemical water quality parameters (DOE, 2016)

WQI = (0.22* SlDO) + (0.19*SIBOD) + (0.16*SICOD) + (0.15*SIAN) + (0.16 * SISS) + (0.12* SipH) …….. (i)

where,
SIDO = Sub index DO (Dissolved oxygen % saturation)
SIBOD = Sub index BOD (Biological oxygen demand)
SICOD = Sub index COD (Carbon oxygen demand)
SIAN = Sub index NH_3–N (Ammoniacal nitrogen)
SISS = Sub index SS (Suspended solid)
SipH = Sub index pH, and
$0 \leq WQI \leq 100$

Best fit equations for the estimation of various sub index values (WEPA, 2006):

Sub index for DO (In % saturation)
SIDO = 0 for $x \leq 8$
SIDO = 100 for $x \leq 92$
SIDO = –0.395 + 0.030 x2 – 0.00020 x3 for $8 < x < 92$

Sub index for BOD
SIBOD = 100.4 – 4.23x for $x \leq 5$
SIBOD = 108*exp(–0.055x) – 0.1x for $x > 5$

Sub index for COD
SICOD = –1.33x + 99.1 for $x \leq 20$
SICOD = 103*exp(–0.0157x) – 0.04x for $x > 20$

Sub index for NH3–N
SIAN = 100.5 – 105x for $x \leq 0.3$
SIAN = 94*exp(–0.573x) – 5* I x – 2 I for $0.3 < x < 4$
SIAN = 0 for $x \geq 4$

Sub index for SS
SISS = 97.5*exp(–0.00676x) + 0.05x for $x \leq 100$
SISS = 71*exp(–0.0061x) + 0.015x for $100 < x < 1000$
SISS = 0 for $x \geq 1000$

Sub index for pH
SlpH = 17.02 – 17.2x + 5.02 x2 for $x < 5.5$
SlpH = –242 + 95.5x – 6.67 x2 for $5.5 \leq x < 7$
SlpH = –181 + 82.4x – 6.05 x2 for $7 \leq x < 8.75$
SlpH = 536 – 77.0x + 2.76 x2 for $x \geq 8.75$

Table S2. Malaysian standards of physio-chemical water quality parameters (DOE, 2016)

Parameters	Unit	Class					
		I	IIA	IIB	III	IV	V
DO	(mg/L)	7	5-7	5-7	3-5	<3	<1
SPC	(μS/cm)	1000	1000	-	-	6000	-
TDS	(mg/L)	500	1000	-	-	4000	-
Salinity	%	0.5	1	-	-	2	-
pH	-	6.5-8.5	6-9	6-9	5-9	5-9	-
Temperature	^{0}C	-	Normal±2	-	Normal±2	-	-

Table S3. One-way ANOVA Test of Water Quality Parameters of River Sampling Points

Parameter	Sum of Squares			Mean Square		F
	Between Groups	Within Groups	Total	Between Groups	Within Groups	
Cd (μg/L)	11.8	6.1	17.9	1.7	0.4	4.4** (p = 0.007)
Cr (μg/L)	0.5	1.2	1.7	0.1	0.1	1 (p = 0.491)
Pb (μg/L)	618.1	48.7	666.8	88.3	3.0	29** (p = 6.1E-8)

**Significant at 0.01 level. *Significant at 0.05 level.

Table S4. Homogeneity Test of Variance and Robust of Equality of Mean

Water Quality Parameter	Levene Test of Homogeneity of Variance	Welch Robust Test of Equality of Mean[1]	Brown-Forsythe Robust Test of Equality of Mean[1]
Cd (μg/L)	8.6*** (p = 2.1E-4)	1240.9*** (p = 6.8E-10)	4.4* (p = 0.087)
Cr (μg/L)	4.6*** (p = 0.006)	6.7*** (p = 0.014)	1 (p = 0.531)
Pb (μg/L)	4.3*** (p = 0.007)	27.2*** (p = 3.8E-4)	29*** (p = 4.4E-4)

[1]Asymptotically F distributed. ***Significant at 0.01 level. **Significant at 0.05 level. *Significant at 0.10 level.

Table S5. One-tailed Correlations of Water Quality Parameters in Langat River (2015)

	Parameters	Cd	Cr	Pb	DO	SPC	Salinity	pH	Temp
Cd	Pearson Correlation	1							
	Sig. (1-tailed)								
Cr	Pearson Correlation	**.798****	1						
	Sig. (1-tailed)	.009							
Pb	Pearson Correlation	**.771***	**.863****	1					
	Sig. (1-tailed)	.013	.003						
DO	Pearson Correlation	**.821****	**.728***	**.612***	1				
	Sig. (1-tailed)	.006	.020	.053					
SPC	Pearson Correlation	**-.883****	**-.632***	-.607	**-.811****	1			
	Sig. (1-tailed)	.002	.046	.055	.007				
Salinity	Pearson Correlation	**-.880****	**-.661***	**-.649***	**-.800****	**.995****	1		
	Sig. (1-tailed)	.002	.037	.041	.009	.000			
pH	Pearson Correlation	-.153	-.230	-.250	.126	.092	.089	1	
	Sig. (1-tailed)	.359	.292	.275	.383	.414	.417		
Temp	Pearson Correlation	**-.837****	**-.868****	**-.781***	**-.852****	**.824****	**.819****	.315	1
	Sig. (1-tailed)	.005	.003	.011	.004	.006	.006	.224	

Note: ***. Correlation is significant at the 0.01 level (1-tailed), **. Correlation is significant at the 0.05 level (1-tailed), *. Correlation is significant at the 0.10 level (1-tailed).

Table S6. Spatial Correlations among Water and Environmental Parameters (2005-2015)

	Parameters	Cd	Cr	Pb	Water Flow	Rainfall	Temp.
Cd	Pearson Correlation	1					
	Sig. (1-tailed)						
Cr	Pearson Correlation	-.123	1				
	Sig. (1-tailed)	.345					
Pb	Pearson Correlation	**.742*****	.170	1			
	Sig. (1-tailed)	.002	.290				
Water Flow	Pearson Correlation	**-.584****	-.352	**-.576****	1		
	Sig. (1-tailed)	.018	.119	.020			
Rainfall	Pearson Correlation	**.484****	.036	**.407***	**-.718*****	1	
	Sig. (1-tailed)	.047	.454	.084	.003		
Temp.	Pearson Correlation	**-.607****	.088	**-.464***	**.648*****	**-.765*****	1
	Sig. (1-tailed)	.014	.387	.055	.008	.001	

Note: ***. Correlation is significant at the 0.01 level (1-tailed), **. Correlation is significant at the 0.05 level (1-tailed), *. Correlation is significant at the 0.10 level (1-tailed).

Table S7. Temporal Correlation among Water and Environmental Parameter 2005-2015

	Parameters	Cd	Cr	Pb	Rainfall	Temp.	Water Flow
Cd	Pearson Correlation	1					
	Sig. (1-tailed)						
Cr	Pearson Correlation	-.171	1				
	Sig. (1-tailed)	.308					
Pb	Pearson Correlation	-.012	**.843*****	1			
	Sig. (1-tailed)	.486	.001				
Rainfall	Pearson Correlation	**-.678****	.156	-.105	1		
	Sig. (1-tailed)	.011	.323	.380			
Temp.	Pearson Correlation	.360	**-.588****	-.372	-.373	1	
	Sig. (1-tailed)	.138	.029	.130	.129		
Water Flow	Pearson Correlation	-.363	-.019	-.195	**.882*****	-.263	1
	Sig. (1-tailed)	.136	.478	.283	.000	.217	

Note: ***. Correlation is significant at the 0.01 level (1-tailed), **. Correlation is significant at the 0.05 level (1-tailed), *. Correlation is significant at the 0.10 level (1-tailed).

Table S8. Shapiro-Wilk Normality Test of River Water Quality Parameters

Parameter	Shapiro-Wilk W	*p* Value
As (μg/L)	0.951	0.279
Cd (μg/L)	0.841	0.001
Pb (μg/L)	0.866	0.004
DO (mg/L)	0.926	0.081
SPC (μS/cm)	0.880	0.008
TDS (mg/L)	0.935	0.123
SAL (ppt)	0.879	0.008
pH	0.903	0.025
Temp ^{0}C	0.830	0.001

Table S9. Determined Physiochemical Water Quality Status in Langat River (2005-2015)

Location	DO (%)	BOD (mg/L)	COD (mg/L)	AN (mg/L)	SS (mg/L)	pH
Pangsoon	101.60±1.98	2.21±0.60	13.92±2.09	0.08±0.03	9.91±3.27	7.39±0.11
Lolo	96.37±1.86	2.31±0.44	14.58±2.98	0.06±0.02	20.87±11.21	7.14±0.13
Serai	101.19±1.82	2.21±0.55	13.92±1.90	0.08±0.03	9.91±2.99	7.38±0.10
Langat	84.29±3.32	7.54±1.90	31.30±6.37	1.48±0.54	370.31±210.43	7.11±0.09
Cheras	76.13±7.11	5.27±0.94	24.78±3.67	1.08±0.68	191.05±60.15	7.04±0.19
Bukit	71.52±9.55	5.27±0.94	24.78±3.67	1.60±0.85	300.28±141.97	7.06±0.16
Salak	89.71±3.46	8.04±1.22	31.53±10.78	0.37±0.12	70.98±34.71	6.99±0.14
Labu	88.46±4.70	2.99±0.68	18.48±4.07	0.37±0.12	70.98±34.71	6.97±0.14
Average	**88.66±4.22**	**4.48±0.91**	**21.66±4.44**	**0.64±0.30**	**130.54±62.43**	**7.14±0.13**
Overall Class	**-**	**III**	**III**	**III**	**III**	**II**

Table S10. National Water Quality Standards for Malaysia (DOE, 2016)

Parameter	Unit	Class					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	–
Total Suspended Solid	mg/l	25	50	50	150	300	300

Table S11. Water Classes and Uses in Malaysia (DOE, 2016)

Class	Uses
Class I	Conservation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
Class IIA	Water Supply II – Conventional treatment. Fishery II – Sensitive aquatic species.
Class IIB	Recreational use body contact.
Class III	Water Supply III – Extensive treatment required. Fishery III – Common, of economic value and tolerant species; livestock drinking.
Class IV	Irrigation
Class V	None of the above.

Table S12. Determined Water Quality Sub Index of Langat River, Malaysia (2005-2015)

Location	DO (%)	BOD (mg/L)	COD (mg/L)	AN (mg/L)	SS (mg/L)	pH
Pangsoon	99.53	91.05	80.59	91.83	91.68	97.50
Lolo	99.22	90.64	79.71	94.16	85.71	98.90
Serai	99.56	91.05	80.59	91.83	91.68	97.58
Langat	92.97	70.59	61.76	42.97	12.97	99.03
Cheras	85.23	80.29	68.82	55.15	25.00	99.24
Bukit	79.90	68.59	61.52	39.66	15.87	98.59
Salak	96.65	87.76	74.53	84.08	63.89	99.65
Labu	95.91	87.76	74.53	84.08	63.89	99.60
Average Sub index	**93.62**	**83.47**	**72.76**	**72.97**	**56.34**	**98.76**
STD.	**7.32**	**9.26**	**7.93**	**23.10**	**33.75**	**0.83**
Overall Category	**-**	**Slightly Polluted**	**-**	**Slightly Polluted**	**Polluted**	**-**
Category Range	**-**	**80 – 90**	**-**	**71 – 91**	**0 – 69**	

Table S13. DOE Water Quality Classification Based on Water Quality Index (DOE, 2016)

Sub Index & Water Quality Index	Index Range		
	Clean	**Slightly Polluted**	**Polluted**
Biochemical Oxygen Demand (BOD)	91 - 100	80 - 90	0 - 79
Ammoniacal Nitrogen (NH_3-N)	92 - 100	71 - 91	0 - 70
Suspended Solids (SS)	76 - 100	70 - 75	0 - 69
Water Quality Index (WQI)	81 - 100	60 - 80	0 - 59

Table S14. Determined Water Quality Index of Langat River, Malaysia (2005-2015)

Location	WQI	Class	Class Range	Category	Category Range
Pangsoon	92.23±6.60	II	76.5 – 92.7	Clean	81 – 100
Lolo	91.51±7.68	II	76.5 – 92.7	Clean	81 – 100
Serai	92.25±6.63	II	76.5 – 92.7	Clean	81 – 100
Langat	64.15±32.12	III	51.9 – 75.5	Slightly Polluted	60 – 80
Cheras	69.20±26.20	III	51.9 – 75.5	Slightly Polluted	60 – 80
Bukit	60.77±29.39	III	51.9 – 75.5	Slightly Polluted	60 – 80
Salak	84.65±13.51	II	76.5 – 92.7	Clean	81 – 100
Labu	84.49±13.36	II	76.5 – 92.7	Clean	81 – 100
Average	**79.91±16.94**	**II**	**76.5 – 92.7**	**Clean**	**81 – 100**

Table S15. DOE Water Quality Index Classification (DOE, 2016)

Parameter	Unit	Class				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/l	< 0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	> 2.7
Biochemical Oxygen Demand	mg/l	< 1	1 – 3	3 – 6	6 – 12	> 12
Chemical Oxygen Demand	mg/l	< 10	10 – 25	25 – 50	50 – 100	> 100
Dissolved Oxygen	mg/l	> 7	5 – 7	3 – 5	1 – 3	< 1
pH	-	> 7.0	6.0 – 7.0	5.0 – 6.0	< 5.0	> 5.0
Total Suspended Solid	mg/l	< 25	25 – 50	50 – 150	150 – 300	> 300
Water Quality Index (WQI)	**-**	> 92.7	76.5 – 92.7	51.9 – 76.5	31.0 – 51.9	< 31.0