water

MDPI

Supplementary Materials: Article

Mining Rock Wastes for Water Treatment: Potential Reuse of Fe- and Mn-Rich Materials for Arsenic Removal

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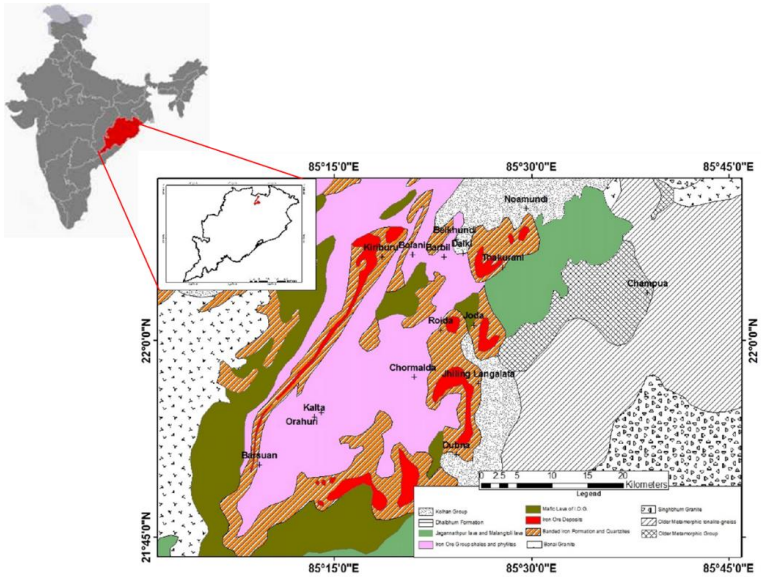

Figure S1. Geological map of Joda West Mine area, Odisha, India [1].

Figure S2. Joda West mining site and waste stockpiles.

Table S1. Part I: Mineral formula and contribution (%) of Fe, Al, Mn to each phase for the calculation of Crystalline phase used to derive semi-quantitative amorphous value. **Part II**: Other mineralogical phases.

Part I.

Fe		
Mineral name	**Mineral Formula**	**Fe%**
Hematite	α-Fe_2O_3	69.8
Goethite	α-FeOOH	62.9
Siderite	$FeCO_3$	48.2
Clinochlore	$Mg_{3.75}Fe^{2+}_{1.25}\ Si_3Al_2O_{10}(OH)_8$	11.73
Staurolite	$(Fe,Mg,Zn)_2(Al,Fe,Ti)_9O_6[(Si,Al)O_4]_4(O,OH)_2$	9.6
Chalcophanite	$Zn_{1.2}Fe^{2+}_{0.5}Mn^{2+}_{0.4}Mn^{4+}_3O_7{\cdot}3(H_2O)$	6.1
Gjerdingenite-Fe	$K_2(H_2O)_2Fe^{3+}_{0.75}Mn^{3+}_{0.25}Nb_3Ti(Si_4O_{12})_2O_3(OH){\cdot}4(H_2O)$	3.4
Krettnichite	$Pb_{0.8}Sr_{0.1}Mn^{3+}_{1.7}Co_{0.2}Fe^{2+}_{0.1}V^{5+}_{1.9}As_{0.1}O_{7.9}(OH)_{2.2}$	1.01
Al		
Mineral name	**Mineral Formula**	**Al%**
Gibbsite	$Al(OH)_3$	34.6
Staurolite	$(Fe,Mg,Zn)_2(Al,Fe,Ti)_9O_6[(Si,Al)O_4]_4(O,OH)_2$	28.9
Berlinite	$AlPO_4$	22.1
Kaolinite	$Al_2Si_2O_5(OH)_4$	20.9
Muscovite	$KAl_3Si_3O_{10}(OH)_{1.8}F_{0.2}$	20.3
Gehlenite	$Ca_2Al_2SiO_7$	19.7
Lazurite	$Na_3CaAl_3Si_3O_{12}S$	16.2
Ellenbergerite	$Mg_6TiAl_6Si_8O_{28}(OH)_{10}$	13.5
Clinochlore	$Mg_{3.75}Fe^{2+}_{1.25}\ Si_3Al_2O_{10}(OH)_8$	9.1
Ferrierite-Na	$Na_{3.06}K_{0.97}Mg_{0.38}Ca_{0.05}Sr_{0.03}Ba_{0.02}Al_5Si_{31}O_{72}{\cdot}18(H_2O)$	5.2
Pyroxene-ideal	$XY(Si,Al)_2O_6$	n.a.
Mn		
Mineral name	**Mineral Formula**	**Mn%**
Pyrolusite	MnO_2	63.2
Birnessite	$Na_{0.3}Ca_{0.1}K_{0.1}Mn^{4+}Mn^{3+}O_4{\cdot}1.5(H_2O)$	50.9
Chalcophanite	$Zn_{1.2}Fe^{2+}_{0.5}Mn^{2+}_{0.4}Mn^{4+}_3O_7{\cdot}3(H_2O)$	40.7
Inesite	$Ca_2Mn^{2+}_7Si_{10}O_{28}(OH)_2{\cdot}5{\cdot}(H_2O)$	29.2
Krettnichite	$Pb_{0.8}Sr_{0.1}Mn^{3+}_{1.7}Co_{0.2}Fe^{2+}_{0.1}V^{5+}_{1.9}As_{0.1}O_{7.9}(OH)_{2.2}$	16.9
Gjerdingenite-Fe	$K_2(H_2O)_2Fe^{3+}_{0.75}Mn^{3+}_{0.25}Nb_3Ti(Si_4O_{12})_2O_3(OH){\cdot}4(H_2O)$	1.1

Part II

Others Mineral Name	Mineral Formula
QUARTZ	SiO_2
ZANAZZIITE	$Ca_2Mg_5Be_4(PO_4)_6(OH)_4 \cdot 6H_2O$
HOPEITE	$Zn3(PO4)_2 \cdot 4(H_2O)$
KOGARKOITE	$Na_3(SO_4)F$
BERLINITE	$AlPO_4$
MAGNESIOCHROMITE	$MgCr_2O_4$

Table S2a. All samples codes, site and colour description, As removal efficiency (% and mg Arsenic/ g material), spectral information and contribution of Crystalline and amorphous fraction of selected major elements (Fe, Al, Mn).

Sample Code	Site Code*	Site Description	% As Removal	mg_{As}/g	Adsorption Class	Powder Colour	Red Band Reflectance	Crystalliniy (Counts Max)	%Fe Crystal	%Fe Amorphous	%Mn Crystal	%Mn Amorphous	%Al Crystal
03-B3	WSD	Waste stokpile+Detritus	19.8%	0.220	Not suitable	brown	0.18	13000	3.0	12.7	0.0	0.4	0.0
06-B1	WS	Waste stockpile	17.2%	0.156	Not suitable	light brown	0.36	12000	11.2	9.3	0.0	1.3	9.3
09-A3	WS	Waste stockpile	22.9%	0.176	Not suitable	dark brown	0.12	12000	15.2	42.9	0.0	7.8	1.3
10-D1	WSD	Waste stokpile+Detritus	16.4%	0.164	Not suitable	light brown	0.38	11000	12.3	6.1	0.0	1.9	8.1
04-B2	WS	Waste stockpile	22.4%	0.236	Not suitable	dark red	0.12	9000	5.2	35.3	0.0	1.0	0.9
04-B4	WSD	Waste stokpile+Detritus	20.9%	0.220	Not suitable	brown	0.30	9000	11.8	15.7	0.7	2.6	2.8
03-C1	RS	Reserve stockpile	1.2%	0.010	Not suitable	dark wine red	0.20	4200	5.1	33.3	0.0	2.8	2.7
04-B3	WSD	Waste stokpile+Detritus	35.1%	0.312	Suitable	brown	0.13	3200	3.7	29.0	0.0	0.6	2.0
10-B1	WSD	Waste stokpile+Detritus	29.5%	0.221	Not suitable	dark red	0.13	3200	5.5	19.5	8.8	0.0	0.0
01-A3	OS	Old stockpile	28.3%	0.265	Suitable	dark red	0.14	3000	3.7	39.5	0.0	1.1	3.9
05-D1	WS	Waste stockpile	18.6%	0.157	Not suitable	dark red	0.13	3000	9.4	13.7	3.0	2.5	0.0
07-B3	WS	Waste stockpile	27.6%	0.249	Suitable	dark red	0.13	2600	5.9	38.6	0.0	2.0	5.1
04-A2	St	Street	18.3%	0.166	Not suitable	dark red	0.11	2400	8.4	25.3	0.0	4.2	2.9

05-A1	WS	Waste stockpile	31.3%	0.330	Suitable	brown	0.20	2400	15.5	15.7	2.1	8.0	4.4
08-B3	WS	Waste stockpile	27.9%	0.227	Not suitable	dark red	0.13	2400	8.6	18.8	1.5	3.4	0.0
03-B4	WS	Waste stockpile	33.1%	0.315	Suitable	dark red	0.16	2200	6.6	31.0	0.0	1.4	6.1
07-A3	WS	Waste stockpile	38.9%	0.433	Promising	dark brown	0.10	2200	11.3	24.3	0.0	3.4	7.5
07-B4	WS	Waste stockpile	34.1%	0.341	Suitable	dark brown	0.13	2200	17.0	21.5	4.9	8.6	0.0
08-B2	WS	Waste stockpile	36.3%	0.330	Suitable	dark red	0.20	2200	13.7	8.4	2.4	0.0	11.2
05-A2	OS	Old stockpile	35.2%	0.392	Promising	dark red	0.15	2100	11.3	26.4	0.0	1.9	11.2
05-B2	WS	Waste stockpile	36.0%	0.400	Promising	dark brown	0.11	2100	16.0	22.3	2.4	8.3	4.9
07-C1	RS	Reserve stockpile	30.0%	0.300	Suitable	blackish	0.07	2100	51.2	3.2	0.2	42.9	1.6
01-A1	OS	Old stockpile	22.3%	0.202	Not suitable	dark brown	0.11	2000	25.4	17.9	23.3	10.9	2.2
06-C1	SA	Storage Area	15.9%	0.127	Not suitable	dark brown	0.08	2000	44.8	0.0	1.7	32.7	3.4
07-C2	RS	Reserve stockpile	29.9%	0.218	Not suitable	blackish	0.07	2000	64.3	0.0	36.6	39.1	0.0
03-A1	SA	Storage Area	29.0%	0.323	Suitable	dark brown	0.12	1900	34.4	3.6	6.1	24.2	4.6
07-B2	WS	Waste stockpile	50.1%	0.456	Promising	dark brown	0.08	1900	20.7	25.2	3.9	13.1	5.4

01-A2	WS	Waste stockpile	24.6%	0.246	Suitable	dark brown	0.11	1700	9.2	40.8	0.0	4.9	5.7
07-B1	WSD	Waste stokpile+Detritus	19.5%	0.154	Not suitable	dark red	0.12	1700	6.6	41.7	0.0	2.4	5.3
06-A1	WS	Waste stockpile	31.1%	0.283	Suitable	dark brown	0.14	1600	26.3	9.5	3.4	15.7	9.5
06-A2	OS	Old stockpile	6.0%	0.045	Not suitable	dark wine red	0.09	1600	5.9	21.7	0.0	3.8	0.0
05-B4	WS	Waste stockpile	32.4%	0.341	Suitable	dark brown	0.15	1500	9.4	13.1	1.6	1.7	0.0
10-B2	WS	Waste stockpile	34.2%	0.311	Suitable	dark red	0.14	1500	10.8	21.1	2.7	1.7	6.6
01-B2	WS	Waste stockpile	23.0%	0.256	Suitable	dark brown	0.11	1400	4.4	0.0	3.7	0.0	2.4
05-C2	WS	Waste stockpile	15.4%	0.162	Not suitable	dark brown	0.09	1400	29.1	10.7	5.3	19.6	0.0
10-A2	St	Street	25.1%	0.228	Not suitable	dark brown	0.11	1400	13.3	29.0	1.4	6.8	6.2
08-D1	WS	Waste stockpile	26.7%	0.281	Suitable	dark red	0.14	1200	7.3	14.8	0.0	1.1	6.6
09-A1	WS	Waste stockpile	23.4%	0.246	Suitable	dark brown	0.15	1200	7.7	22.6	2.8	2.3	2.3
08-B1	WS	Waste stockpile	27.0%	0.284	Suitable	dark brown	0.13	1100	15.5	19.2	5.8	7.1	3.3
10-A1	St	Street	27.6%	0.276	Suitable	dark brown	0.14	1100	10.4	21.7	3.7	3.1	2.8
05-C1	RS	Reserve stockpile	29.1%	0.220	Not suitable	blackish	0.07	1000	70.3	4.1	0.2	58.3	3.7

09-D1	WSD	Waste stokpile+Detritus	43.1%	0.392	Promising	dark brown	0.10	1000	34.9	11.4	1.6	26.1	5.1
02-A2	OS	Old stockpile	32.6%	0.326	Suitable	dark brown	0.08	800	27.9	0.0	11.3	17.4	0.0
02-B4	SA	Storage Area	30.0%	0.273	Suitable	dark brown	0.16	800	23.7	0.0	4.2	10.9	5.0
04-A1	SA	Storage Area	23.1%	0.220	Not suitable	dark brown	0.08	800	26.4	2.6	10.2	16.6	0.0
04-C1	RS	Reserve stockpile	17.9%	0.153	Not suitable	blackish	0.17	800	76.3	4.9	5.2	62.6	1.4
10-A3	WS	Waste stockpile	34.8%	0.348	Promising	dark brown	0.08	800	31.9	2.3	8.5	21.8	0.0

***Old Stockpile (OS)**: mining rock wastes that have been accumulated for many years and now covered with herbaceous vegetation; **Waste stockpile (WS)**: mining rock wastes accumulated along mining way; **Storage Area (SA):** area within the mine where the extracted materials, rich in Fe and Mn, are accumulated and stored; **Waste stokpile+Detritus (WSD)**: mining rock wastes accumulated in open space covered by a large quantity of detritus coming down from the mining walls; **Street**: mining rock wastes used for road building of the mining site; **Reserve stockpile**: Fe and Mn very rich stockpiles that have been stored for future use.

Table S2b. All samples codes with major (%, yellow) and minor (mg/kg, cyan) elements measured by XRF.

Sample	Major Elements (%)								Minor Elements (mg/kg)												
Code	**Al**	**Fe**	**Mn**	**Ca**	**K**	**Mg**	**Si**	**Ti**	**As**	**Ce**	**Cr**	**Cu**	**La**	**Mo**	**Ni**	**P**	**Pb**	**Rb**	**S**	**Y**	**Zn**
01-A1	2.2	39.0	34.3	0.2	1.3	0.2	3.2	0.3	36.0	1.5	126.3	69.4	18.5	167.0	344.9	281.9	0.3	41.4	172.5	15.2	305.9
01-A2	5.7	73.2	4.9	0.1	0.3	0.1	4.2	0.4	48.6	18.3	143.7	23.1	9.1	14.4	127.0	292.7	109.0	37.1	216.7	31.3	75.7
01-A3	3.9	81.3	1.1	0.0	0.2	0.0	3.7	0.5	2.8	23.3	256.5	46.6	53.8	17.9	0.8	360.7	29.1	34.8	226.2	32.8	124.5
01-B2	4.6	45.6	1.6	0.1	0.8	0.1	21.3	0.3	22.0	23.1	281.5	19.9	24.3	15.8	48.6	385.8	47.8	47.5	109.8	41.1	101.6
02-A2	2.3	53.5	28.7	0.2	0.6	0.1	2.4	0.3	86.0	35.4	241.9	34.9	86.8	79.0	352.0	234.5	137.0	30.1	199.4	13.4	183.8
02-B4	11.3	29.5	15.1	0.2	1.0	0.2	11.9	0.7	2.8	117.0	225.2	44.6	15.2	179.0	497.9	453.3	1360.0	34.5	291.1	97.7	154.5
03-A1	4.6	35.1	30.3	0.1	1.8	0.1	5.3	0.4	2.8	46.3	193.9	32.2	11.5	125.0	236.0	365	273.0	33.1	460.6	28.9	316.3
03-B3	3.1	20.9	0.4	0.1	0.5	0.1	40.5	0.2	108.9	24.6	107.1	10.4	25.3	3.8	23.2	391.6	10.7	38.8	108.5	17.6	57.2
03-B4	6.7	75.9	1.4	0.1	0.3	0.0	6.2	0.2	26.2	25.6	169.4	37.9	39.9	31.3	0.8	93.3	78.0	57.9	36.1	6.2	150.4
03-C1	2.6	85.7	2.8	0.0	0.6	0.0	2.5	0.1	2.8	1.5	103.8	12.2	1.5	0.2	0.8	476.9	50.0	71.5	81.8	85.3	108.4
04-A1	2.4	54.8	26.7	0.2	0.9	0.1	2.7	0.2	85.8	1.5	350.8	30.1	15.4	208.0	372.1	232.7	258.0	45.3	162.6	17.1	286.6
04-A2	4.6	76.4	4.2	0.0	0.2	0.0	5.4	0.3	2.8	64.2	649.2	19.1	118.1	16.4	68.0	443.4	240.0	40.8	243.4	48.0	68.9
04-B2	4.9	50.6	1.0	0.1	2.0	0.2	20.3	0.4	63.7	38.0	195.2	8.1	49.8	8.8	0.8	320.1	50.5	39.7	49.2	15.9	75.4
04-B3	3.9	84.0	0.6	0.0	0.2	0.0	3.7	0.2	17.1	80.4	368.2	39.7	180.7	6.5	0.8	211.1	80.2	112.6	26.6	35.1	125.2
04-B4	10.4	20.3	3.3	0.1	4.7	0.9	31.3	1.0	2.8	47.3	646.4	25.0	32.6	35.7	319.5	299.2	102.5	50.9	40.2	186.9	188.9
04-C1	1.4	17.6	67.8	0.1	2.4	0.1	1.6	0.0	3.8	1.5	109.3	26.1	35.8	190.0	179.2	678.8	30.9	47.2	66.1	64.3	296.6
05-A1	6.6	39.2	10.1	0.1	1.7	0.3	13.0	0.5	139.8	25.3	432.2	82.4	34.1	78.0	689.2	513.2	276.0	23.2	215.3	35.8	432.6
05-A2	12.2	58.0	1.9	0.0	0.2	0.0	11.0	0.8	54.2	175.9	472.3	36.5	284.2	33.1	249.9	321.5	475.0	39.9	76.7	30.9	146.4
05-B2	6.7	50.2	10.7	0.1	0.8	0.1	10.2	0.4	32.7	48.1	515.1	20.7	10.6	97.0	212.8	208	573.0	28.4	193.2	6.9	166.6
05-B4	8.0	62.3	3.2	0.1	0.7	0.1	9.2	0.5	2.8	57.2	338.8	18.5	46.1	24.0	165.0	234.3	217.0	45.9	61	53.9	54.0
05-C1	3.7	17.2	58.4	0.1	2.5	0.1	3.4	0.2	2.8	23.6	65.3	27.2	20.6	170.0	79.5	429.5	263.0	37.1	91.9	60.4	153.6
05-C2	4.1	49.8	24.9	0.1	1.1	0.1	5.7	0.3	40.4	18.7	254.2	33.4	11.2	112.0	360.6	292.2	304.0	42.9	77.6	28.3	277.2
Code	**Al**	**Fe**	**Mn**	**Ca**	**K**	**Mg**	**Si**	**Ti**	**As**	**Ce**	**Cr**	**Cu**	**La**	**Mo**	**Ni**	**P**	**Pb**	**Rb**	**S**	**Y**	**Zn**

05-D1	6.0	70.0	5.5	0.1	0.5	0.1	6.4	0.4	2.8	41.1	218.8	21.8	39.0	22.1	158.1	390.2	116.0	39.9	56.3	57.0	116.6
06-A1	9.5	30.6	19.1	0.1	1.1	0.1	10.4	0.8	15.8	104.5	169.2	24.6	74.2	109.0	193.4	251	675.0	62.7	82.8	1.1	251.8
06-A2	1.6	87.4	3.8	0.1	0.2	0.0	0.8	0.1	2.8	1.5	173.5	17.4	1.5	0.2	0.8	456.5	0.3	34.8	80	64.9	29.4
06-B1	12.7	9.3	1.3	0.1	5.5	1.4	39.5	1.3	11.5	95.4	846.2	20.3	26.2	8.4	310.8	350.7	109.2	32.1	149.8	30.8	194.0
06-C1	6.9	21.6	34.4	0.2	2.1	0.3	10.0	0.5	2.8	135.3	121.1	23.5	68.8	137.0	223.5	359.9	614.0	45.0	64	47.8	83.0
07-A3	9.6	58.0	3.4	0.1	0.4	0.1	10.3	0.5	62.7	139.1	368.4	21.9	118.7	29.1	73.2	294.1	438.0	40.6	53.5	12.6	93.9
07-B1	5.3	80.8	2.4	0.0	0.1	0.0	5.1	0.2	33.4	8.7	131.5	18.2	35.3	0.2	171.0	410.9	120.0	38.2	473.5	24.3	109.2
07-B2	5.4	58.7	17.0	0.1	0.6	0.1	3.5	0.3	87.0	42.6	277.2	32.4	8.7	94.0	54.2	555.5	715.0	48.1	373.9	19.4	114.5
07-B3	5.1	77.7	2.0	0.1	0.6	0.1	5.3	0.3	14.1	32.7	233.0	23.3	22.1	9.1	94.0	339	111.0	42.8	110.5	36.2	158.4
07-B4	5.4	59.0	13.5	0.1	1.0	0.1	8.2	0.3	2.8	40.6	153.9	29.8	25.4	65.0	214.2	117.8	408.0	36.9	121.9	34.9	175.2
07-C1	1.6	28.3	43.1	0.1	2.1	0.0	7.1	0.1	2.8	20.4	57.6	16.5	14.0	116.0	48.6	463.3	282.0	18.4	46.1	192.7	81.7
07-C2	0.5	15.6	75.8	0.1	1.0	0.0	0.8	0.0	42.2	21.6	52.6	15.1	84.2	263.0	128.3	408	28.3	51.0	182.5	92.6	151.2
08-B1	5.7	60.8	12.9	0.1	1.3	0.1	6.2	0.6	88.4	32.5	323.2	28.8	15.6	62.0	254.3	206.1	285.0	18.5	121.3	28.3	215.6
08-B2	17.2	33.0	1.0	0.0	0.4	0.1	16.2	0.8	57.9	145.6	160.2	15.9	149.6	32.1	63.2	313.5	231.6	41.8	107.3	35.4	60.7
08-B3	4.6	69.9	4.9	0.1	0.4	0.0	6.5	0.3	2.8	34.8	254.5	19.2	15.7	26.1	201.8	445.7	241.0	43.6	188	60.8	102.0
08-D1	8.0	56.0	1.1	0.1	0.4	0.1	8.8	0.3	52.6	55.9	525.6	18.5	31.5	15.3	1.5	345.6	107.8	46.7	106.9	19.2	79.6
09-A1	4.6	72.3	5.1	0.1	0.5	0.0	5.5	0.3	80.1	15.3	191.7	16.6	1.5	17.2	127.3	284.6	190.0	45.1	217.9	35.7	145.1
09-A3	7.3	51.8	7.8	0.1	1.0	0.1	11.6	0.5	37.6	55.7	299.7	28.3	41.9	53.1	322.6	408	359.0	45.0	57.7	44.4	199.3
09-D1	5.1	38.4	27.7	0.1	1.1	0.1	4.5	0.3	68.4	39.8	129.4	71.5	42.3	100.0	1914.0	357.4	628.0	45.1	111.8	27.3	394.9
10-A1	6.3	65.2	6.8	0.1	0.6	0.1	8.3	0.4	64.7	70.6	394.7	35.9	61.9	50.6	233.5	354.9	436.0	42.9	98.2	32.5	173.7
10-A2	6.2	54.8	8.2	0.2	0.7	0.1	8.9	0.4	2.8	90.6	719.8	32.9	44.9	75.4	202.7	504.5	714.0	35.3	131.8	73.7	171.6
10-A3	2.5	51.0	30.3	0.1	0.6	0.0	2.3	0.2	58.5	22.9	166.5	33.5	56.3	138.0	460.0	345.9	231.0	49.0	49.9	20.2	312.3
10-B1	4.2	76.3	4.2	0.0	0.2	0.0	4.4	0.3	55.8	33.9	386.5	33.9	9.3	7.0	148.0	179	229.0	33.4	69.2	24.7	154.9
10-B2	9.8	58.2	4.4	0.1	0.4	0.1	9.3	0.8	60.3	85.3	309.3	23.9	39.6	31.8	155.4	288.2	496.0	44.1	169.8	28.2	111.2
10-D1	13.1	8.9	1.9	0.1	5.5	1.2	36.3	1.3	2.8	65.6	741.0	19.6	36.2	18.6	311.6	505.6	85.9	49.7	190.2	86.0	119.2

Table S2c. All samples codes with mineralogical phases major (PartI) and minor (PartII) (%) measured by XRD. Other phase is the sum of all minor phases. n.d. = not detectable phases.

Part I: Major phases (%)

Code	Crystallinity (Counts Max)	Hematite	Goethite	Kaolinite	Pyrolusite	Quartz	Other Phases
01-A1	2000	4.8	28.2	n.d.	36.9	n.d.	30.0
01-A2	1700	39.8	7.2	17.6	n.d.	6.6	28.8
01-A3	3000	47.6	13.6	38.8	n.d.	n.d.	n.d.
01-B2	1400	46.1	22.8	11.5	5.8	13.8	n.d.
02-A2	800	52.6	29.4	n.d.	18.0	n.d.	n.d.
02-B4	800	34.8	10.0	24.1	6.7	16.6	7.8
03-A1	1900	45.1	n.d.	25.0	9.6	n.d.	20.3
03-B3	13000	7.4	4.8	n.d.	n.d.	87.8	n.d.
03-B4	2200	42.1	24.7	29.1	n.d.	4.0	n.d.
03-C1	4200	70.0	n.d.	n.d.	n.d.	n.d.	30.0
04-A1	800	44.0	34.1	n.d.	16.1	5.9	n.d.
04-A2	2400	63.7	4.7	n.d.	n.d.	n.d.	31.7
04-B2	9000	19.9	2.2	4.2	n.d.	73.6	n.d.
04-B3	3200	50.1	27.7	n.d.	n.d.	n.d.	22.3
04-B4	9000	3.6	3.3	n.d.	n.d.	78.0	15.1
04-C1	800	3.9	8.7	n.d.	5.1	7.1	75.2
05-A1	2400	11.7	24.3	n.d.	n.d.	35.6	28.4
05-A2	2100	33.7	12.9	53.4	n.d.	n.d.	n.d.
05-B2	2100	34.4	6.3	n.d.	n.d.	20.2	39.1
05-B4	1500	58.2	8.0	n.d.	n.d.	23.5	10.4
05-C1	1000	11.8	n.d.	n.d.	n.d.	6.3	81.9
05-C2	1400	49.9	6.9	n.d.	8.4	34.9	n.d.
05-D1	3000	70.7	11.1	n.d.	n.d.	5.6	12.5
06-A1	1600	30.3	n.d.	n.d.	n.d.	9.2	60.5
06-A2	1600	81.5	14.1	n.d.	n.d.	4.5	n.d.
06-B1	12000	n.d.	n.d.	10.6	n.d.	54.3	35.1
06-C1	2000	32.7	n.d.	n.d.	n.d.	35.2	32.2
07-A3	2200	48.3	n.d.	35.9	n.d.	15.8	n.d.
07-B1	1700	50.9	5.8	34.2	n.d.	9.2	n.d.
07-B2	1900	41.4	7.4	n.d.	3.8	13.0	34.5
07-B3	2600	44.2	13.2	33.8	n.d.	8.8	n.d.
07-B4	2200	47.5	6.8	n.d.	3.6	26.3	15.9
07-C1	2100	24.8	3.2	n.d.	n.d.	19.7	52.3
07-C2	2000	7.3	16.3	n.d.	57.6	n.d.	18.8
08-B1	1100	48.0	12.8	15.8	9.2	14.3	n.d.
08-B2	2200	31.2	4.5	49.5	n.d.	2.4	12.5
08-B3	2400	59.4	15.2	n.d.	n.d.	22.3	3.0
08-D1	1200	40.1	21.0	31.5	n.d.	7.4	n.d.
09-A1	1200	51.5	21.8	11.0	4.5	11.2	n.d.
09-A3	12000	12.8	n.d.	n.d.	n.d.	81.3	5.9
09-D1	1000	31.1	8.3	20.0	n.d.	6.7	33.9
10-A1	1100	37.9	27.1	13.2	5.9	15.8	n.d.
10-A2	1400	31.6	5.9	n.d.	n.d.	33.0	29.5
10-A3	800	48.5	23.6	n.d.	13.4	14.5	n.d.
10-B1	3200	61.7	21.8	n.d.	3.2	n.d.	13.4
10-B2	1500	48.5	5.2	31.4	4.3	10.7	n.d.

Part II: Minor phases (%)

Sample Code	Birnessite	Gibbsite	Chalcophanite	Siderite	Zanazzite	Krettnichite	Clinochlore	Muscovite	Ellenbergerite	Hopeite	Pyroxene-ideal	Gjerdingenite-Fe	Ferrierite-Na	Berlinite	Staurolite	Magnesiochromite	Ineseite	Gehlenite	Lazurite
01-A1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	30.04	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
01-A2	n.d.	28.84	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
01-A3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
01-B2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
02-A2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
02-B4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
03-A1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	20.34	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
03-B3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
03-B4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
03-C1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	29.98	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
04-A1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

04-A2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	31.66	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
04-B2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
04-B3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	22.25	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
04-B4	1.4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	13.74	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
04-C1	n.d.	n.d.	4.93	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	26.21	n.d.	n.d.	n.d.	44.09	n.d.	n.d.	n.d.	n.d.
05-A1	2.91	n.d.	n.d.	n.d.	n.d.	3.93	n.d.	21.55	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
05-A2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
05-B2	4.75	6.11	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	20.51	7.75	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
05-B4	3.11	n.d.	n.d.	7.24	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
05-C1	n.d.	7	n.d.	n.d.	11.82	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	14.43	n.d.	n.d.	46.06	n.d.	n.d.	n.d.	n.d.
05-C2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
05-D1	5.86	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	6.63	n.d.	n.d.	n.d.
06-A1	6.66	53.82	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
06-A2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

06-B1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	35.06	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
06-C1	3.38	n.d.	n.d.	n.d.	11.82	n.d.	n.d.	16.97	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
07-A3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
07-B1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
07-B2	2.85	31.66	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
07-B3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
07-B4	5.09	n.d.	n.d.	n.d.	10.77	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
07-C1	n.d.	n.d.	n.d.	4.3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	15.6	n.d.	n.d.	32.36	n.d.	n.d.	n.d.	n.d.
07-C2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	18.75	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
08-B1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
08-B2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	8.26	4.23	n.d.
08-B3	3.03	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
08-D1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
09-A1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

09-A3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	5.86	n.d.	n.d.	n.d.	n.d.	n.d.
09-D1	n.d.	9.72	n.d.	n.d.	n.d.	9.37	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	14.83	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10-A1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10-A2	2.84	10.4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	16.27
10-A3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10-B1	13.35	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10-B2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10-D1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	27.16	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Table S3. European soil and sediments major and minor elements content (mg/kg) (**FOREGS geochemical Atlas** http://weppi.gtk.fi/publ/foregsatlas/index.php). **FOREGS** = FORum of European Geological Surveys.

	Median	**Max**	
Al_2O_3	10.40%	32.60%	floodplain
	11.00%	27.60%	topsoils
Fe_2O_3	3.33%	35.80%	floodplain
	3.51%	22.30%	topsoils
MnO	0.07%	6.61%	floodplain
	6.00%	0.78%	topsoils
SiO_2	64.60%	100%	floodplain
	67.70%	96.70%	topsoils
TiO_2	0.48%	2.15%	floodplain
	0.57%	5.45%	topsoils
As (mg/kg)	6	390	floodplain
	7.03	280	topsoils
Ce (mg/kg)	50.2	231	floodplain
	48.2	270	topsoils
Cr (mg/kg)	59	2700	floodplain
	60	6200	topsoils
Cu (mg/kg)	17	500	floodplain
	12.9	260	topsoils
La (mg/kg)	24.9	130	floodplain
	23.5	140	topsoils
Mo (mg/kg)	0.62	190	floodplain
	0.6	21.3	topsoils
Ni (mg/kg)	22	1100	floodplain
	18	2700	topsoils
P2O5	0.11%	2.61%	floodplain
	0.13%	1.32%	topsoils
Pb (mg/kg)	22	7100	floodplain
	22.6	970	topsoils
Rb (mg/kg)	71	540	floodplain
	79.5	390	topsoils
S (mg/kg)	290	5400	floodplain
	230	112000	topsoils
Y (mg/kg)	20.1	130	floodplain
	21	270	topsoils
Zn (mg/kg)	65	5000	floodplain
	52	2900	topsoils

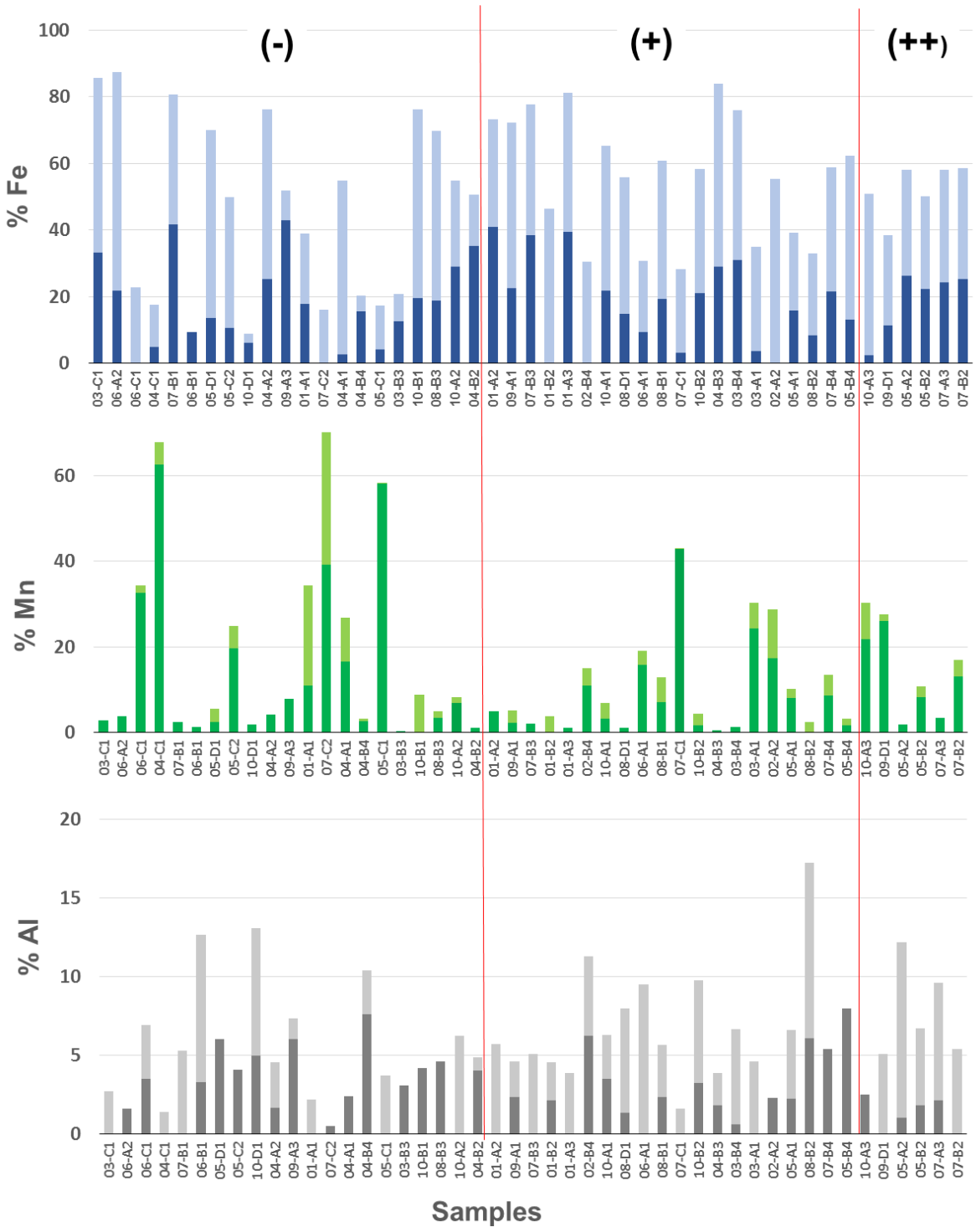

Figure S3. Amorphous (dark bars) and crystalline (light bars) contribution to overall presence of Fe (blue), Mn (green) and Al (grey) divided into As adsorption groups: (-) "Not Suitable", (+) "Suitable) and (++) "Promising". Samples were ordered by increasing As adsorption capacity (from left to right). Semi-quantitative contribution (%) of amorphous fraction for Fe, Mn and Al is given by subtracting by XRD data (% crystalline phases) from XRF measurements (% Total element).

Reference:

1. Mishra, P., Mishra, S.K., Singh, P.P., Kumar Mohapatra, B. 2016. Reworked manganese ore bodies in Bonai-Keonjhar belt, Singhbhum Craton, India: Petrology and genetic study. Ore Geology Reviews, vol. 78, 361-370.