

Supporting materials

Text S1 Method for determining basic peach quality and soil physicochemical characteristics

The basic quality of peach was determined according to the Agricultural Industry Standard of the People's Republic of China NY/T 844-2017. The analytical balances (ML304T, Mettler Toledo, Switzerland), abbe refractometer (WYA-2S, Shanghai Yidian Physics & Optics Instrument Co., Ltd., China), 0.1 mol/L NaOH (Guaranteed Reagent grade, Sinopharm Chemical Reagent Co., Ltd., China), and anthrone method were used to determine the edible rate, soluble solids, titratable acidity, and soluble sugar of peach. The organic matter, available N, P and K in soil were determined according to the classical agrochemical methods. The pH value of soil was measured using a soil to ultrapure water ratio of 1:5 (w/v) by a pH meter (FE20, Mettler Toledo, Switzerland) according to ISO 10390: 2005. Soil As was separated into water-soluble, surface-adsorbed, Fe/Al-associated, acid-extractable and residual fractions based on sequential extraction, among which the water-soluble and surface-adsorbed As can be considered as available As. The available Cd concentration in soil was determined using the diethylenetriaminepentaacetic acid (DTPA) extraction method according to GB/T 23739-2009.

Text S2 Method of evaluation of agricultural sustainability

Agricultural sustainability of different phytoremediation strategies was determined for evaluating the feasibility of intercropping patterns on large-scale application in As-/Cd-contaminated orchards. According to Li et al. (2023), agricultural sustainability can be classified by soil quality and crop production. The parameters for evaluating soil productivity and transformation of As/Cd include soil pH value, organic matter, available N, P, K as well as available As/Cd according to the United Nations Sustainable Development Goals (SDGs) indicator metadata 15.3.1. Indicators reflecting peach production include fruit yield, As/Cd concentration and basic quality (edible rate, soluble solids, titratable acidity and soluble sugar). The specific data for all indicators were obtained from the field trials in this study (Fig. 2, Fig. S5, Table S3). The scoring method is as follows:

$$S_{score} = \sum (H/H_{max} \times W) \times 100$$

S_{score} represents the agricultural sustainability score, H represents the input value for each indicator, H_{max} represents the maximum input value for each indicator, and W represents the weight of each indicator. Soil quality and crop production have equal weighting (0.5) based on Li et al. (2023). The weight of soil pH, organic matter, available As/Cd, and available N, P, K is 0.125, 0.125, 0.125, 0.0417, 0.0417 and 0.0417, respectively. The weight of peach yield, As/Cd concentration, edible rate, soluble solids, titratable acidity and soluble sugar is 0.166, 0.166, 0.0415, 0.0415, 0.0415 and 0.0415, respectively.

Table S1 Specific costs of four phytoremediation scenarios.

Costs ^a		MP ^b	LP ^c	MH ^d	LH ^e
		yuan/hm ²			
Fundamental costs	Accumulator seedlings	124500	93000	52500	39000
	Transplanting	7500	5625	7500	5625
Operational costs	Land rent ^e	45000	45000	45000	45000
	Fertilizers for accumulators	27750	20820	2475	1860
	Fertilizers for peach	0	17850	0	17850
	Pesticides	0	3000	150	3000
	Water and electricity fees	3000	3000	3000	3000
	Irrigation	1500	1500	1500	1500
	Fertilization	4500	5625	1500	3375
	Weeding	30000	22500	17250	12945
	Harvest of peach	0	3000	0	3000
	Mowing of accumulators	3750	2820	3750	2820
	Drying of accumulators	300	225	300	225
	Milled and granulated	4500	3375	4500	3375
	Disposal	24660	22320	24660	23295

^a The land rent was determined based on the market price for land transfer in peach orchards within Pinggu District according to Beijing Public Resource Trading Service Platform. The costs of procurement and disposal of accumulators were derived from previous studies (Guo et al., 2022; Yang et al., 2023), while labor and other material costs were determined based on the average local market prices. ^b *P. vittata* monoculture; ^c *P. vittata*/peach intercropping; ^d *H. spectabile* monoculture; ^e *H. spectabile*/peach intercropping.

Table S2 Accounting method and varieties for GEP of different phytoremediation scenarios.

Ecological Services	Quantity indicators	Calculation	Details	Varieties	Values	Reference				
EPV	Peach Production	$B_p = A \times P \times Y_p$	B_p : annual profit of peach production (yuan/a); A : area (hm^2); Y_p : yield (kg/hm^2); P : unit price of peach (yuan/kg).		2.5	Market price				
ERV	Water retention	$B_W = A \times J_0 \times K_0 \times R \times P_w$	B_W : economic benefit of water retention (yuan/a); J_0 : annual precipitation (mm); K_0 : percentage of precipitation generating runoff; R : difference in runoff rate between farmland and bare land; P_w : reservoir filling cost (yuan/t).	J_0	644	Annual precipitation data (Zhao et al., 2004a, 2004b; Zhao et al., 2019)				
				K_0	0.4					
				R	0.2					
				P_w	1.17					
	Soil retention	$B_S = A \times A_c \times \lambda \times \frac{P_d}{\rho}$	B_S : economic benefit of sediment reduction (yuan/a); A_c : soil conservation quantity ($\text{t}/(\text{hm}^2 \text{ a})$); λ : coefficient of sediment accumulation, 24%; P_d : unit cost of reservoir dredging (yuan/ m^3); ρ : soil capacity (t/m^3).	A_c	15.3	(Chen et al., 2008; Zhao et al., 2022; Yang et al., 2023) (Ouyang et al., 2013) (Ministry of Ecology and Environment, 2002) This study				
				λ	0.24					
				P_d	12.6					
				ρ	1.12					
				Soil protection fertility	$B_F = A \times \sum_i A_c \times \frac{C_i}{R_i} \times P_i$		B_F : economic benefit of soil fertility protection (yuan/a); C_i : N, P, and K concentrations in soil (g/kg); R_i : percentage of N, P and K in fertilizer, N: $\text{CO}(\text{NH}_2)_2 = 0.46:1$, P: $\text{Ca}(\text{H}_2\text{PO}_4)_2 \cdot \text{H}_2\text{O} = 0.052:1$, K: $\text{KCl} = 0.52:1$; P_i : average price of N, P and K fertilizer (yuan/t).	C_N	0.89	This study (Cao et al., 2021)
								C_P	1.60	
C_K	2.00									
R_N	0.46									
R_P	0.052									
R_K	0.52									
Soil protection			P_N	3000	Market price					
			P_P	900						
			P_K	2630						

Ecological Services	Quantity indicators	Calculation	Details	Varieties	Values	Reference
	Reduction of Cd pollution diffused	$B_{HM} = A_r \times P_{AM} \times (C_M - C_S)$	B_{AM} : economic benefit of As-/Cd-contamination control (yuan/a); P_{AM} : unit cost of As/Cd removal (yuan/g Cd); C_M : As/Cd concentration in soil (mg/kg); C_S : As/Cd concentration risk intervention values for agricultural land (mg/kg).	P_{AM}	Actual data	This study, Fig. S1
	Carbon sequestration	$B_C = A \times S_C \times \frac{M_{CO_2}}{M_C} \times P_{CS}$	B_C : economic benefit of carbon sequestration (yuan/a); S_C : carbon fixation quantity (t/(ha a), 10% of accumulator above-ground biomass is converted to soil organic carbon; according to IPCC recommend value, the amount of CO ₂ fixation by woody crop is 0.355 t/(hm ² a); P_{CS} : carbon emissions trading price in China (yuan/t), according to National Carbon Market Development Report in China (2024).	S_C S_C for peach M_{CO_2} M_C P_{CS}	for Actual data 44 12 56.6	(Cicerone and Oremland, 1988) (Ouyang et al., 2020) Molecular weight (Ministry of Ecology and Environment, 2024)
	Oxygen release	$B_O = A \times V_{OX} \times P_{OX}$	B_O : economic benefit of oxygen release (yuan/a); V_{OX} : oxygen release quantity (t (hm ² a)), according to the principle of photosynthesis, 1.0 g dry matter will be released 1.2 g O ₂ . $V_{OX} = 1.2 \times \text{dry matter}$; P_{OX} : price of oxygen (yuan/t), cost of oxygen release from afforestation is 103 yuan/t.	V_{OX} P_{OX}	Actual data 103	(Lu et al., 2018)
	Air Purification	$B_A = A \times C_i \times P_i$	B_A : economic benefit of air purification (yuan/a); C_i : gas i absorption capacity per unit area (kg/(hm ² a)); A : area; P_i : unit price of gas i reduction (yuan/kg); $i = 1, 2, 3$ represent SO_2 , NO_x , and PM , according to Environmental Protection Tax Law of the People's Republic of China (2018 Revision) and Environmental tax standards of Beijing.	C_{SO_2} accumulaors C_{NO_x} accumulaors C_{PM} accumulaors C_{SO_2} for peach C_{NO_x} for peach C_{PM} for peach P_{SO_2} P_{NO_x}	for 0.9 for 0.6 for 120 4.5 3.35 0.095 12.64 12.64	(Ouyang et al., 2020) (Zou et al., 2020) (State Taxation Administration, 2016; The Standing Committee of Beijing Municipal People's

Ecological Services	Quantity indicators	Calculation	Details	Varieties	Values	Reference
				P_{PM}	3	Congress, 2018)
ECV	Basic livelihood security of rural laborers without sufficient arable land	$B_{CV} = Q \times P_M \times E \times A$	B_{CV} : economic benefit of social security (yuan/a); Q : ratio of rural population of lowest life guarantee to arable area (People/hm ²); P_M : minimum living standard (yuan/(People a)); E : ratio of annual average per capita cost between rural and urban residents.	Q_N P_M E	0.37 15840 0.52	(Cai et al., 2020)

Table S3 Effect of accumulator intercropping on quality parameters of peach.

Tested sites	Phytoremediation scenarios	Edible rate (%)	Soluble solids (%)	Titrateable acid (%)	Soluble sugar (%)
As-contaminated soil	Peach monoculture ^a	92.39	10.2	0.42	8.36
	<i>P. vittata</i> /peach intercropping	92.99	10.4	0.434	8.49
Cd-contaminated soil	Peach monoculture	92	12.8	2.15	8.13
	<i>H. spectabile</i> /peach intercropping	92.2	12	1.91	7.98

^a Peach monoculture referred to the original peach cultivation area at the tested As-/Cd-contaminated sites as control.

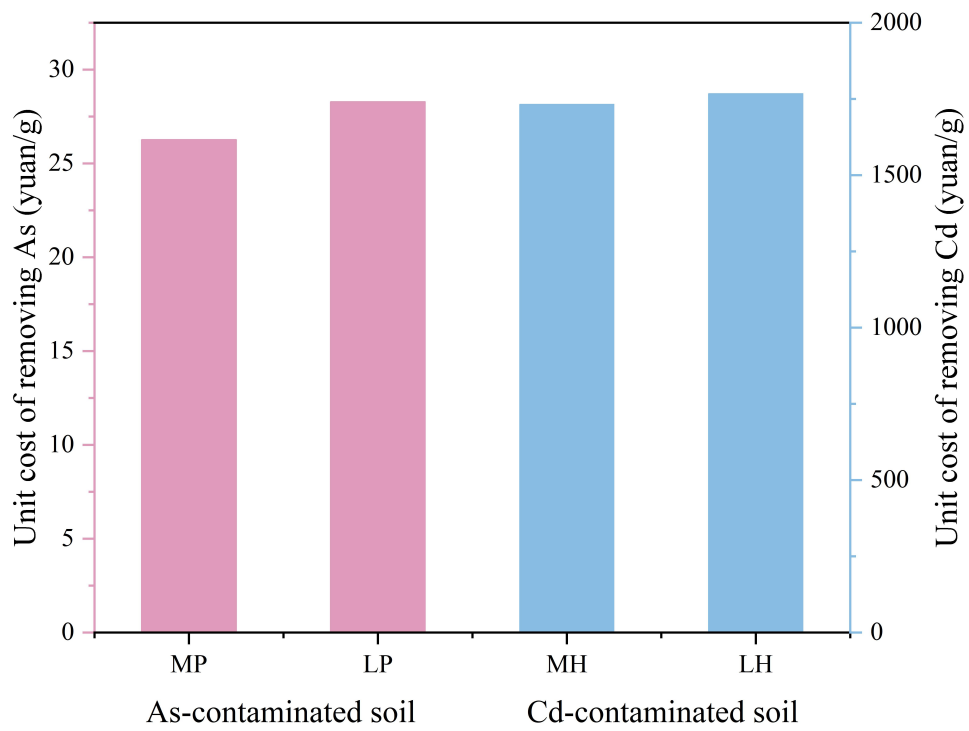


Fig. S1 Unit cost of removing per gram of As/Cd in soil under different phytoremediation patterns.

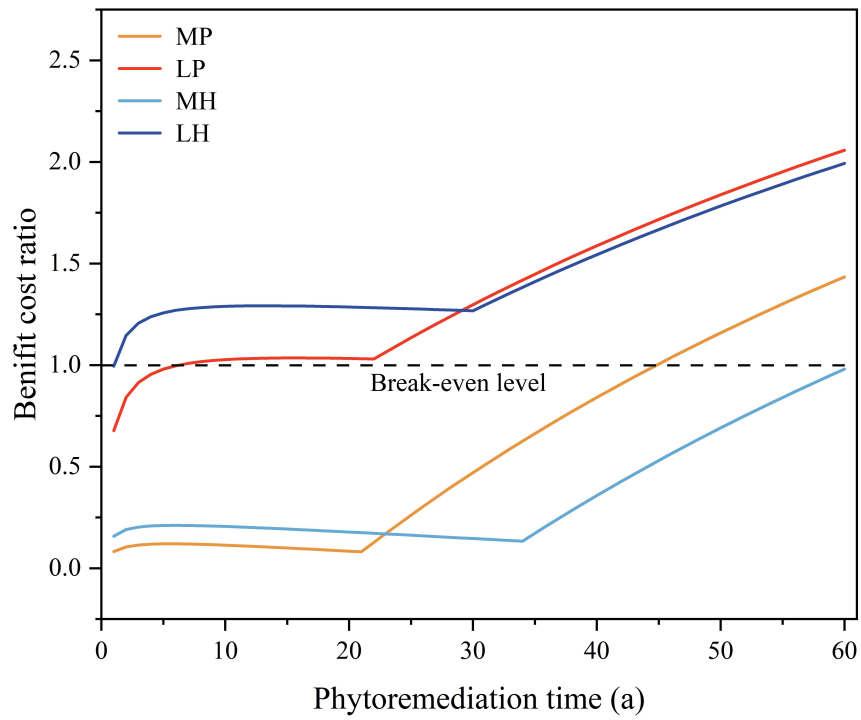


Fig. S2 The benefit-cost ratios of different phytoremediation modes at As/Cd-contaminated soils over a 60 years lifetime.

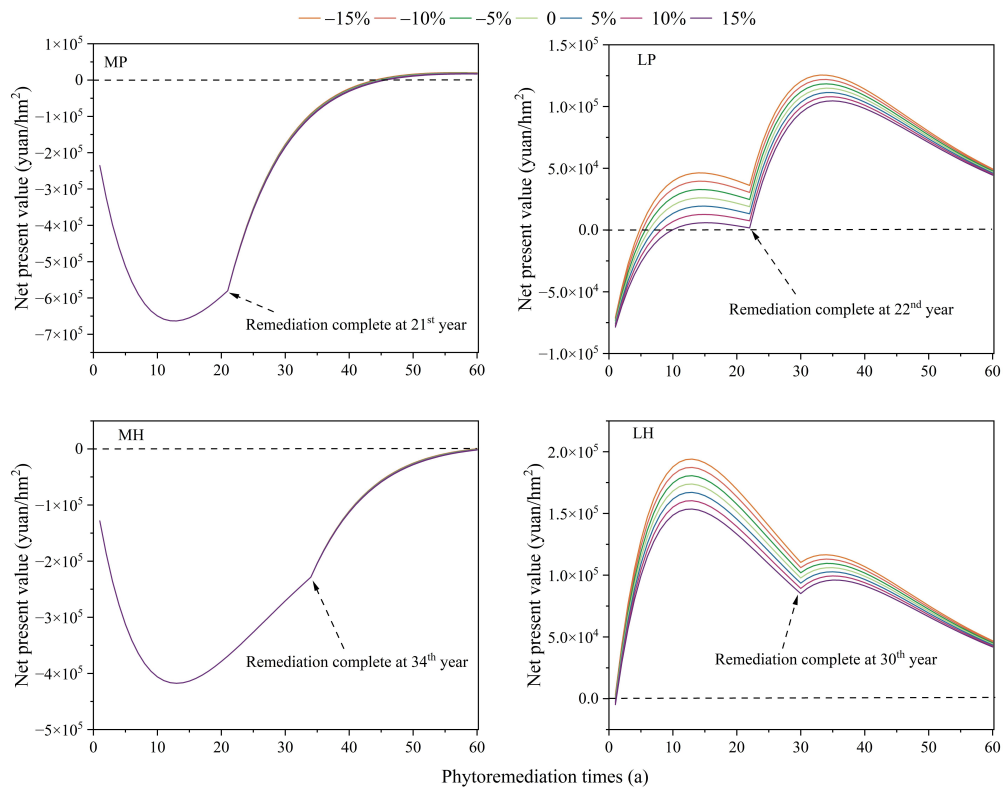


Fig. S3 Uncertainty in net present value calculation of different phytoremediation scenarios caused by costs of peach cultivation.

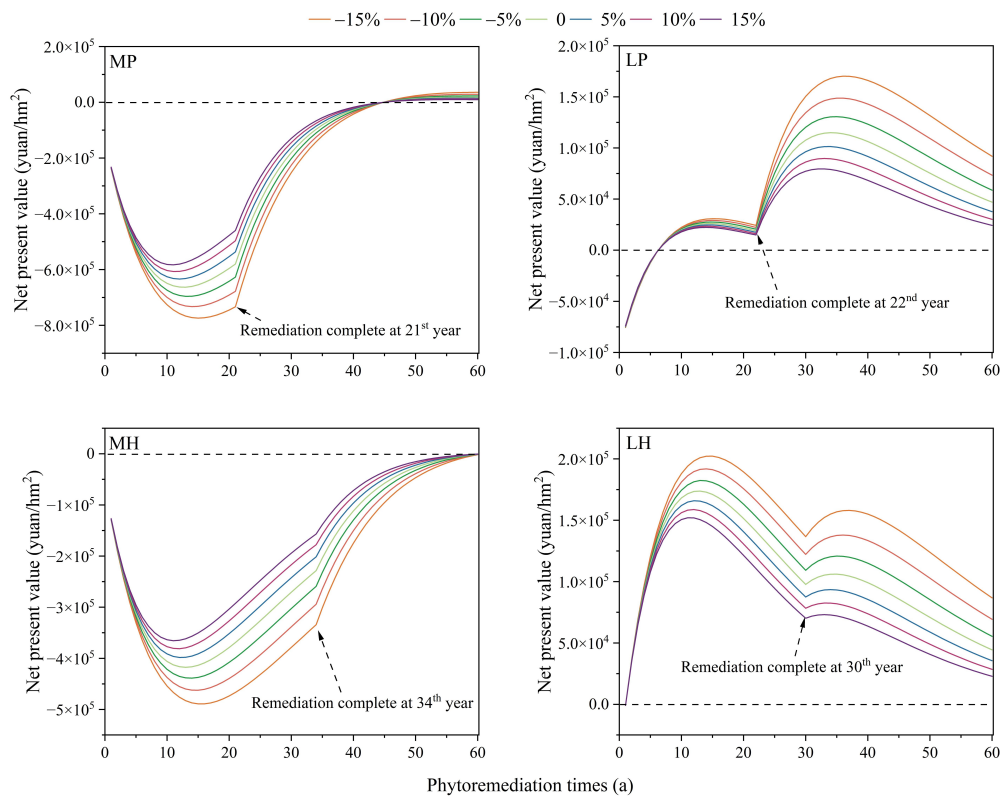


Fig. S4 Uncertainty in net present value calculation of different phytoremediation scenarios caused by financial discount rate.

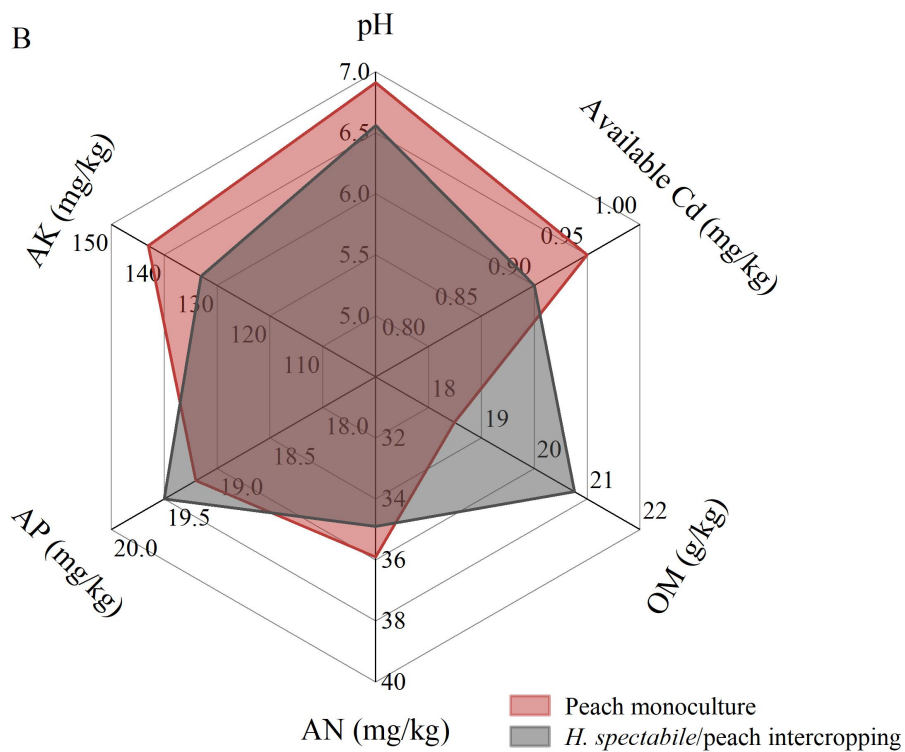
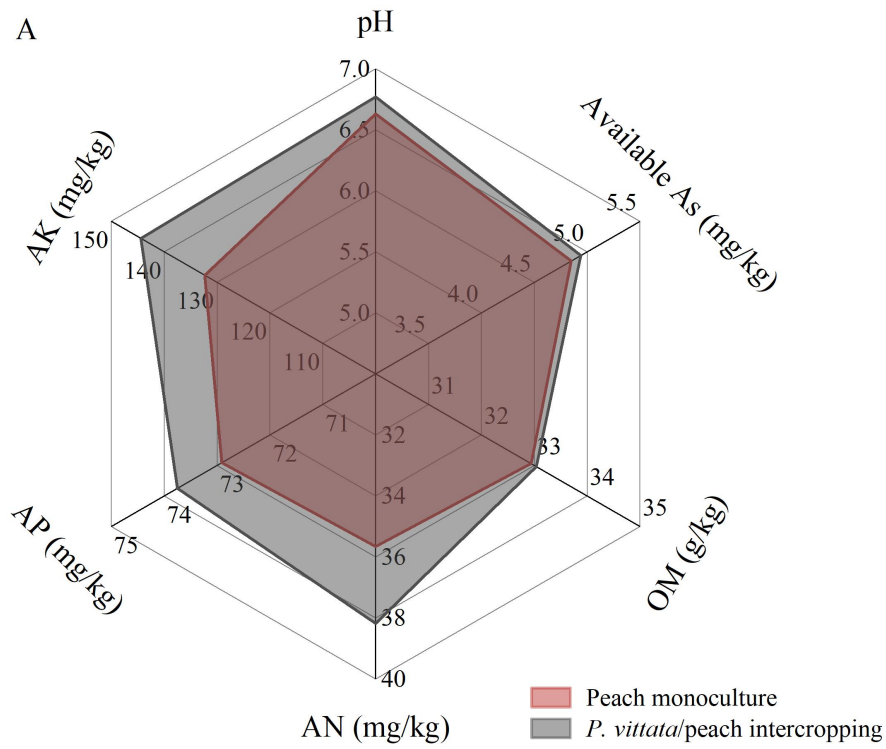


Fig. S5 Available As/Cd concentration and physiochemical properties in rhizosphere soils under different phytoremediation scenarios (A: at As-contaminated soil; B: at Cd-contaminated soil). OM, AN, AP, AK referred to the organic matter, available N, P, K in rhizosphere soils, respectively. Peach monoculture referred to the original peach cultivation area at the tested As-/Cd-contaminated sites as control.

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