8th International R&D conference on Global Trends in Water Resources, Power & RE Sectors

Biochar selection for agricultural runoff treatment: impact of biochar source and processing conditions

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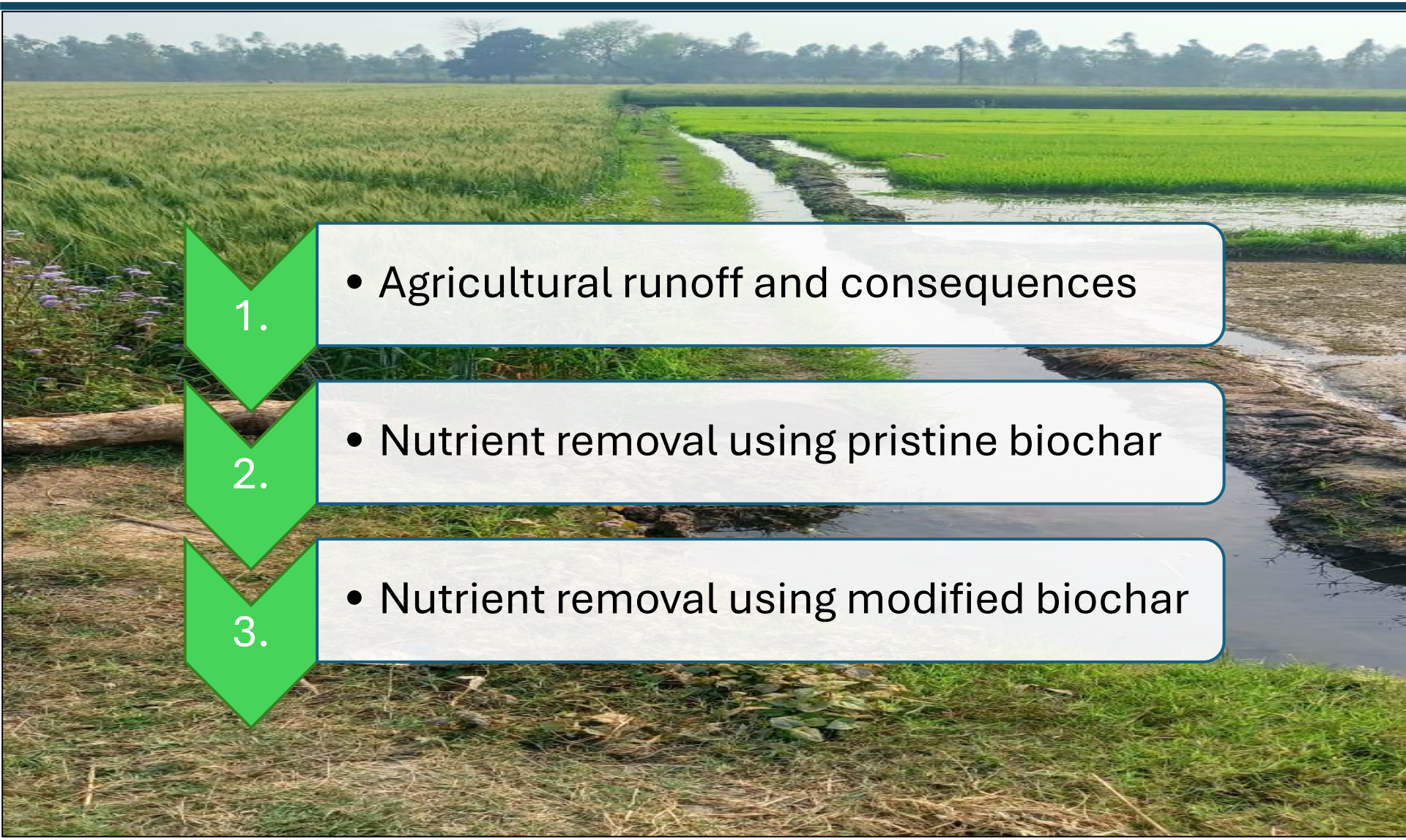
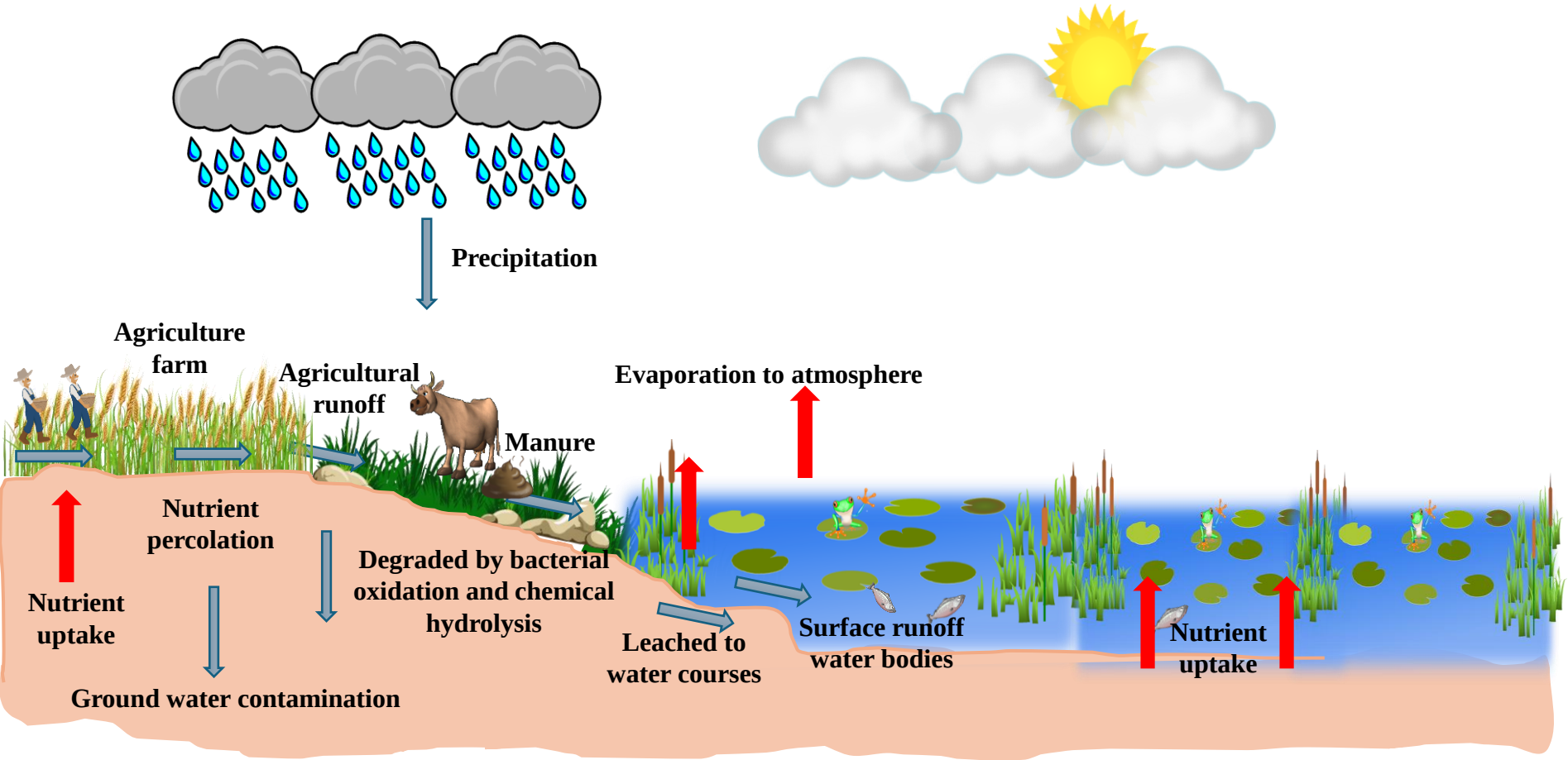
Outline



1. Agricultural runoff and consequences
2. Nutrient removal using pristine biochar
3. Nutrient removal using modified biochar

Agricultural runoff

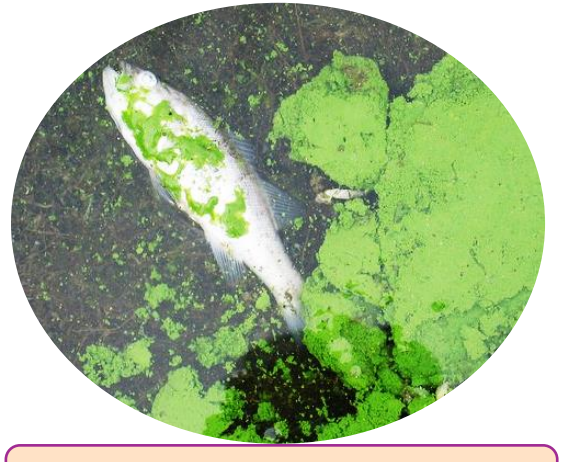


Runoff (carrying nutrients such as nitrogen, phosphorus and potassium)
Runoff (by irrigation and rainfall)

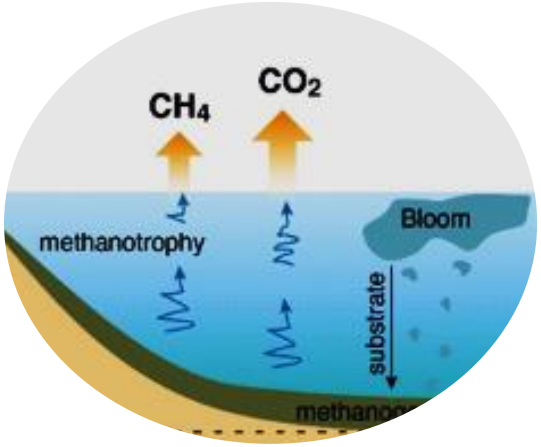
Nutrient uptake

Agricultural runoff consequences

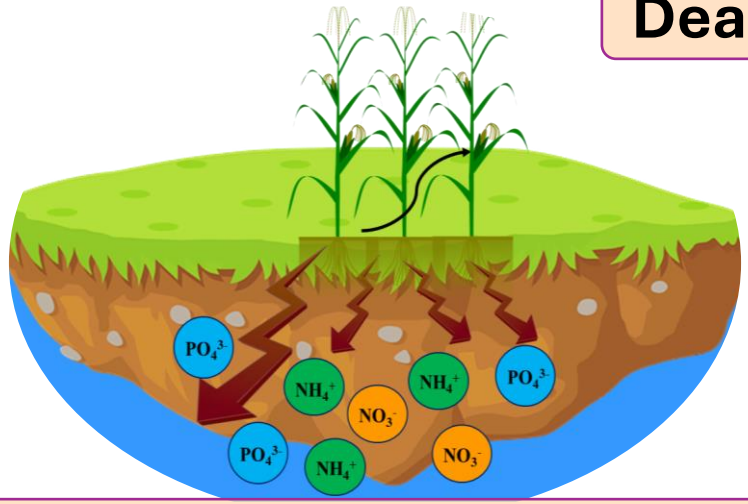
Eutrophication



Dead aquatic life



GHGs emission



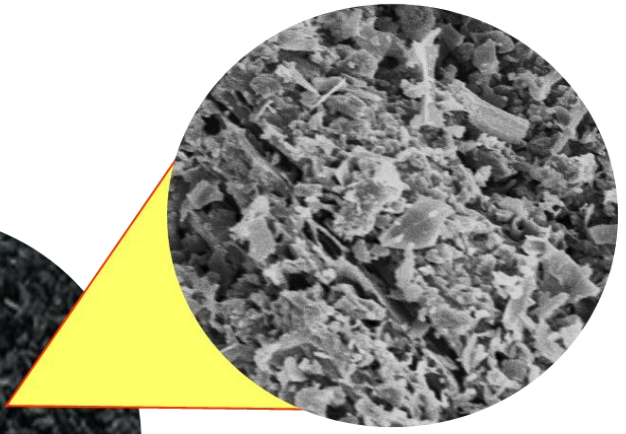
Ground water contamination

Public health threats

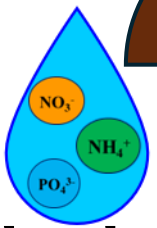
Agricultural runoff treatment using Biochar

Waste Biomass

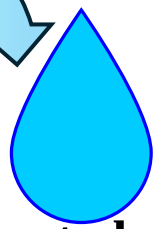
Pyrolysis



Biochar – a porous carbon material

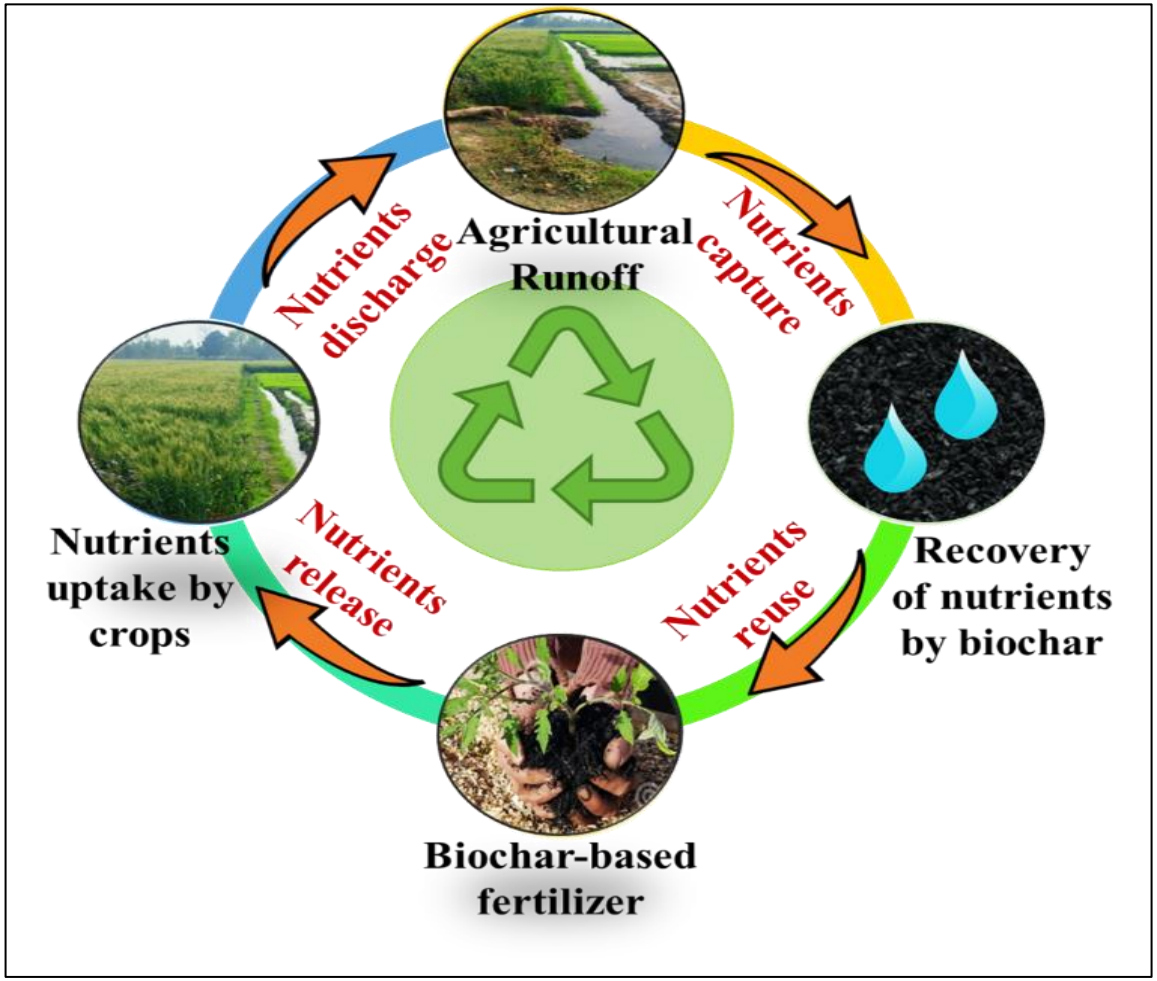


Polluted water

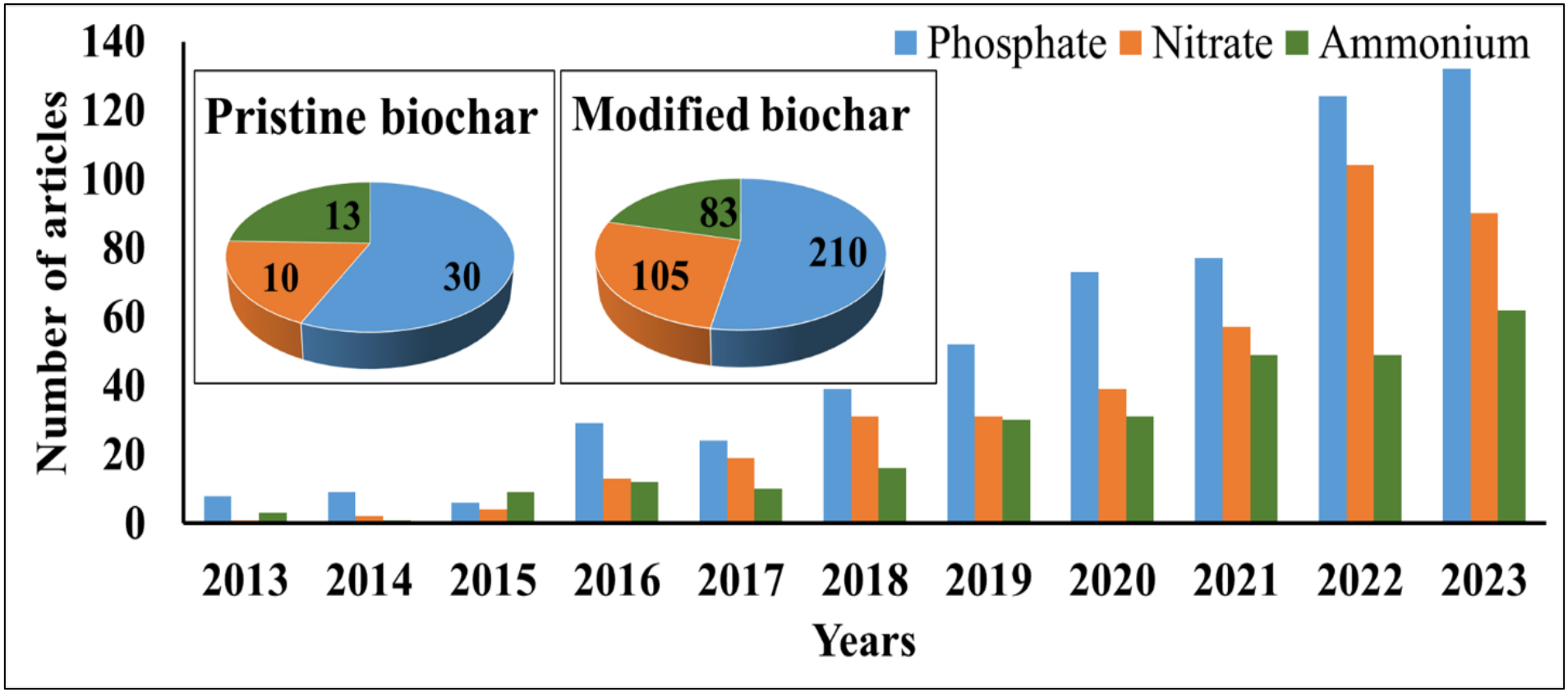


Treated water

Biochar: An ecofriendly material for nutrient recycling in a circular economy framework

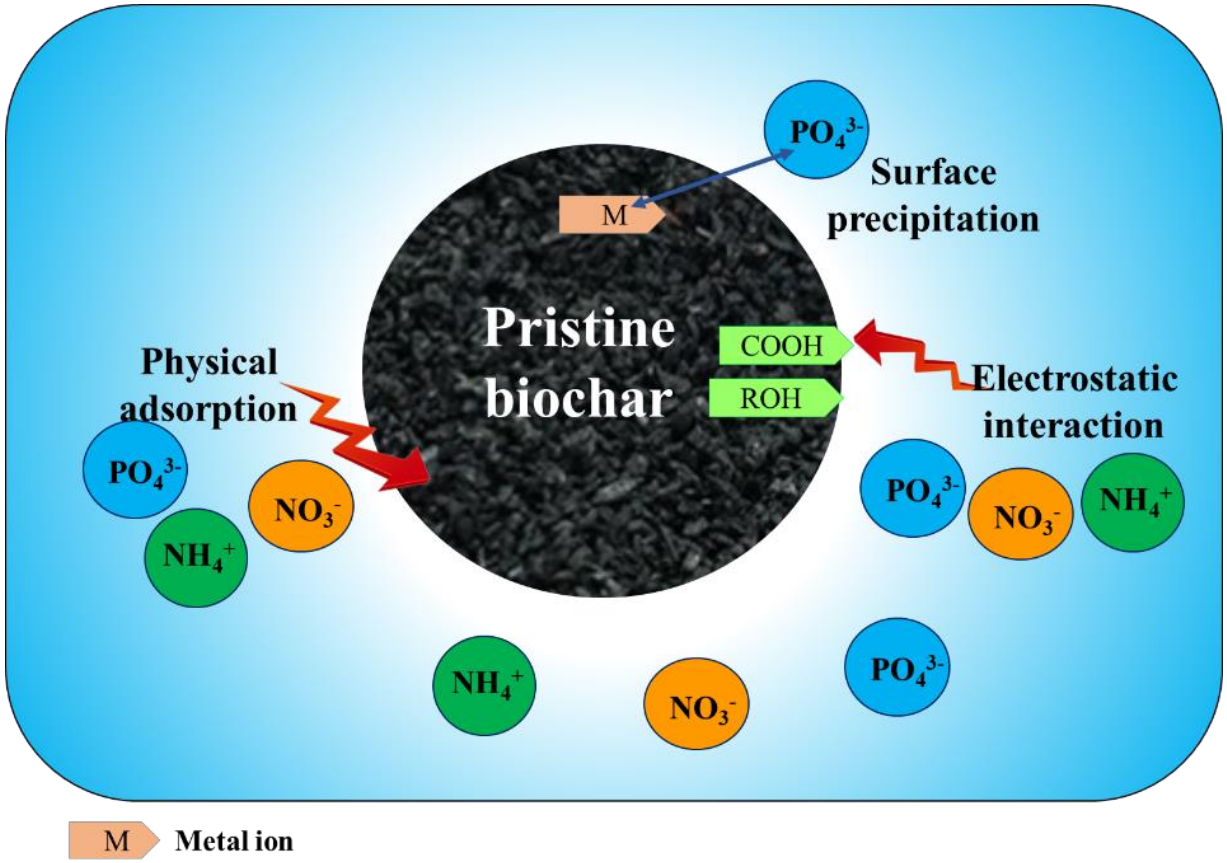


Nitrate, ammonium, and phosphate removal using biochar



Scopus database

Pristine biochar



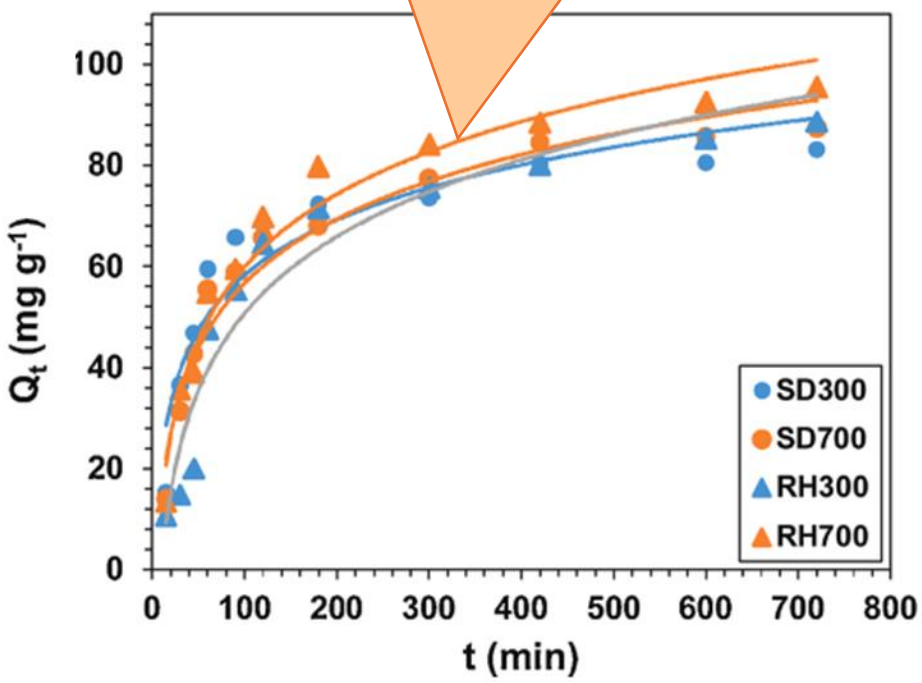
Ammonia, nitrate and phosphate removal using pristine biochar

Pristine biochar

Biomass	Reactor	Processing conditions	Biochar property		Nutrient removed	Dominating mechanism	Reference
			Specific surface area (m^2/g)	Pore volume (cm^3/g)			
Corn straw	Oven	240 °C; 24 h; N_2	15.12	0.1826	NH_4^+	Chemisorption	(Wang et al., 2023)
Walnut shell	Tube reactor	200-700 °C; 20 °C/min; 0.5-2.5 h; N_2	7.9	0.062	PO_4^{3-}	-	(Yang et al., 2023)
Pig manure	Muffle furnace	500 °C; 10 °C/min; 2 h; O_2	12.27	0.026	PO_4^{3-}	Surface precipitation and Electrostatic attraction	(Nardis et al., 2022)
	Horizontal furnace	500 °C; 10 °C/min; 2 h; N_2 (200 mL/min)	11.54	0.031			
Saw dust	Muffle furnace	300 °C; 5 °C/min; 2 h; limited O_2	0.758	0.0021	PO_4^{3-}	Pore diffusion and chemisorption	(Fatima et al., 2021)
		700 °C; 5 °C/min; 2 h; limited O_2	7.544	0.0200	NO_3^-	Chemisorption	
Rice husk		300 °C; 5 °C/min; 2 h; limited O_2	0.144	0.0004	PO_4^{3-}	Pore diffusion and chemisorption	
		700 °C; 5 °C/min; 2 h; limited O_2	0.852	0.0033	NO_3^-	Chemisorption	
Rice straw	Pilot-scale biochar plant	400 °C; 2 h	42.11	0.1143	NO_3^- and PO_4^{3-}	Electrostatic attraction and surface precipitation	(Chandra et al., 2020)
		600 °C; 2 h	110.34	0.1815	NH_4^+	Surface diffusion	
Biosolids	Microwave chamber	600 °C; 2 h; N_2	55.55	0.135	PO_4^{3-}	Precipitation	(Antunes et al., 2018)

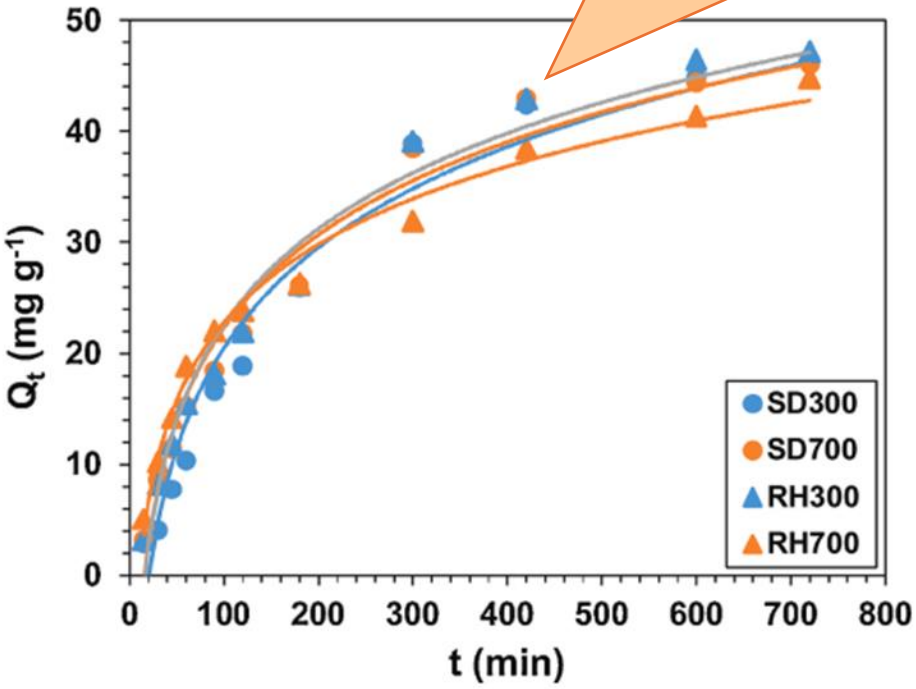
Pristine biochar

- Rice husk-based biochar
- Pyrolysis temperature 700^{0}C



Nitrate adsorption

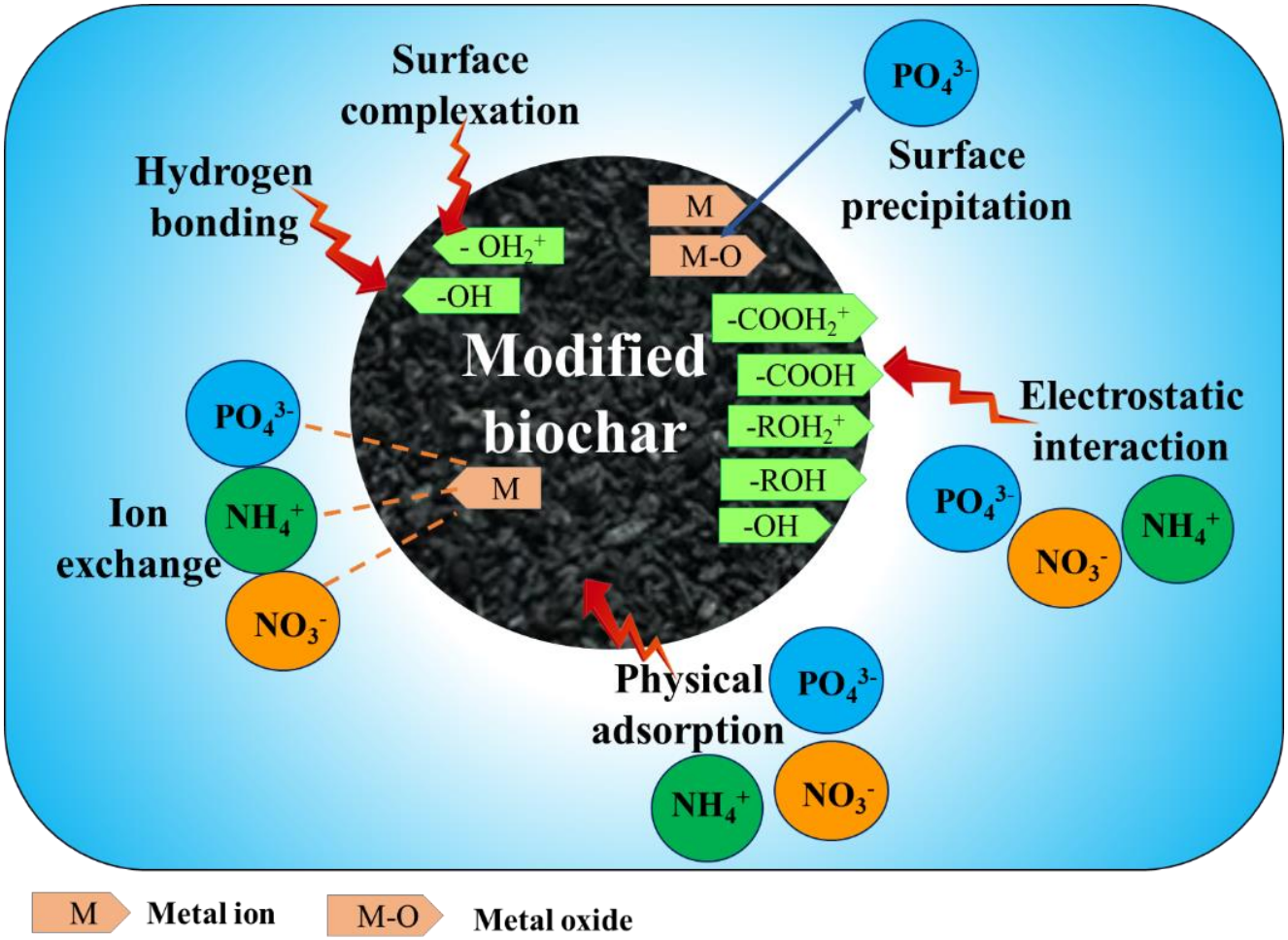
- Rice husk-based biochar
- Pyrolysis temperature 700^{0}C



Phosphate adsorption

Fatima et al., 2021

Modified biochar

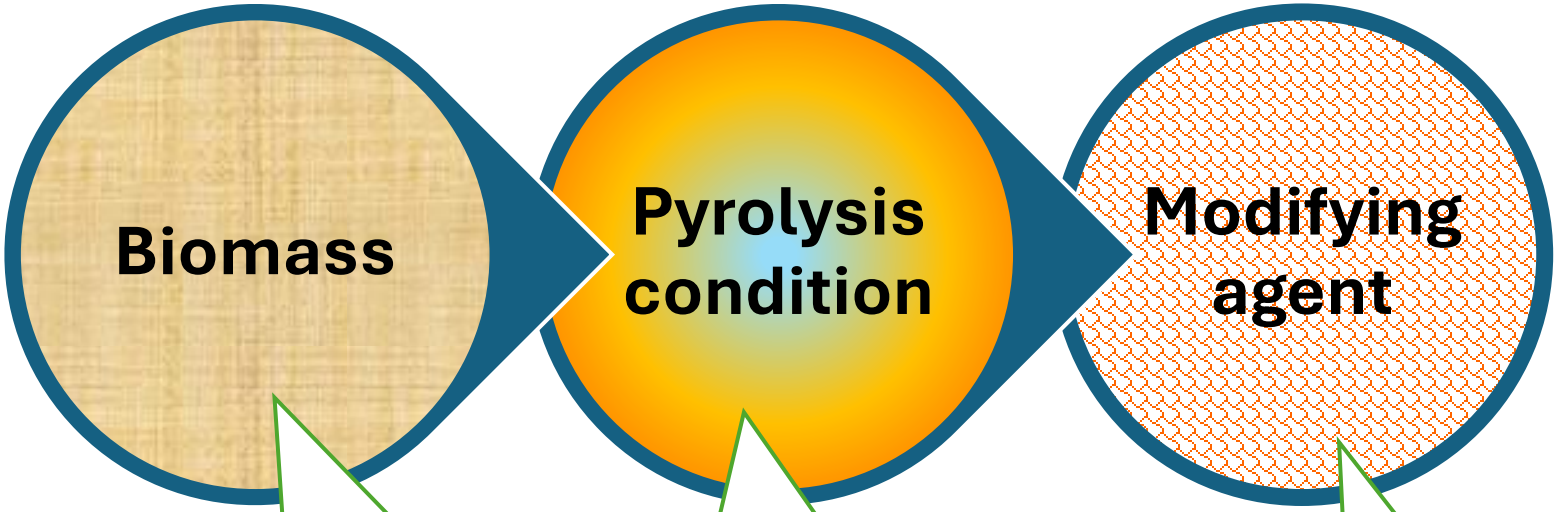


Ammonia, nitrate and phosphate removal using modified biochar

Modified biochar

Biomass	Modifying agent	Reactor	Processing conditions	Biochar property		Nutrient removed	Dominating mechanisms	References
				Specific surface area (m^2/g)	Pore volume (cm^3/g)			
Corn straw	KOH, $FeCl_3$	Oven	240 °C; 24 h; N_2	15.12	0.182	NH_4^+	Chemisorption	(Wang et al., 2023)
Pig manure	$MgCl_2$	Muffle furnace	500 °C; 10 °C/min; 2 h; O_2	23.76	0.103	PO_4^{3-}	Surface precipitation and electrostatic attraction	(Nardis et al., 2022)
	$AlCl_3$			10.40	0.013			
	$MgCl_2$	Horizontal furnace	500 °C; 10 °C/min; 2 h; N_2 (200 mL/min)	33.78	0.129			
	$AlCl_3$			7.07	0.023			
Rape straw	Eggshell	Tube electrical furnace	800 °C; 1.5 h; N_2	181.32	0.090	PO_4^{3-}	Electrostatic attraction, Ca-P precipitation, and hydrogen bonding	(Cao et al., 2020)
	$CaCO_3$			32.23	0.024			
Rice straw	$FeCl_3$ and KOH	Pilot-scale biochar plant	400 °C; 2 h	69.23	0.194	PO_4^{3-} and NO_3^-	Surface precipitation and electrostatics attraction	(Chandra et al., 2020)
			700 °C; 2 h	189.22	0.325	NH_4^+	Surface diffusion	
Rice straw	$Ca(OH)_2$	Tube furnace	600 °C; 2 h; N_2	9.87	0.019	PO_4^{3-}	Chemical precipitation and ligand exchange	(Liu et al., 2019b)
			700 °C; 2 h; N_2	16.10	0.032			
			800 °C; 2 h; N_2	28.90	0.107			
Biosolids	$Ca(OH)_2$ (7% wt.)	Microwave chamber	700 °C; 0.33 h; N_2	48.63	0.125	PO_4^{3-}	Precipitation	(Antunes et al., 2018)
	$Ca(OH)_2$ (11% wt.)			50.70	0.132			
	$Ca(OH)_2$ (20% wt.)			54.40	0.142			

Modified biochar – design consideration



Key factors influencing biochar properties and nutrient removal

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