The Nature of Saline and Alkaline Soils of the Peruvian Coastal Zone

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The Peruvian coastal zone consists of a narrow strip of land which extends the whole length of the country from the border of Ecuador in the north to the border of Chile in the south; to the east it is limited by the foothills of the western range of the Andes, and to the west by the Pacific Ocean.

Its length is approximately 2,000 kilometres, its width varies from less than 5 kilometres in the south to over 100 kilometres in the north and it lies between 3° and 18° south latitude and between 70° and 82° west longitude. The total area is about 145,000 square kilometres, which represents 11.3% of the total area of the country, but the area fit for economic exploitation is about 10% of this total, owing to the desert nature of much of the zone. In this area live 28.9% of the total population of Peru. The density of population is 21.5 per square kilometre. The agricultural importance of the coastal zone is fundamental because it supports crops of high export value, such as cotton, sugar cane, rice, fruits and so forth.

The rainfall is so scanty in the centre and south of this coastal zone that it hardly reaches 50 mm. annually, whereas in the north it is as much as 300 mm. a year. The annual mean temperatures lie between 16 and 24.3 °C, the latter being in the north. The rainfall is so low that it has no direct effect on the production of the crops, nor does it produce any effective leaching of the soils.

In regard to the geomorphological character of the zone, of especial interest are the so-called "tablazos marinos" or low-lying coastal plains in the north and centre of the country, and in the south the "pampas", both of which are of marine origin and therefore potentially rich in salts.

In recent years the salinity of the cultivated lands has been increasing, and it has been calculated that between 25 and 30% of the land under cultivation is affected to a greater or lesser degree by salts, while large areas are in fact going out of cultivation every year.

The genesis of these soils has been affected by one or more factors, such as the arid conditions, the extreme heat and evaporation during the summer, low-lying topography, intensive and often inefficient irrigation practices, high water-table, poor drainage, etc. Therefore a proper identification of these soils and a classification based on genetic principles will be valuable in bringing about their improvement. Soil surveys carried out in different parts of the Peruvian coast have shown that almost all the soils are saline and/or alkaline in nature.

Table 1.

Chemical analysis of the soils of the arid northern coastal zone
1. Chao and Viru "Pampas"

Sample No.	Depth cm	Saturation percentage	pH	Electrical conductivity mmhos./cm.	Cation exchange capacity me./100 g.	Exchangeable-cations me./100 g.				Saturation extract determination anions me./100 g.			
						Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO^{2-}	CO_3^{2-}	HCO_3^-
1	0–20	19.2	7.4	75.00	3.6	0.2	0.5	2.6	0.3	9.5	10.4	0	0
	20–40	18.2	7.0	220.01	5.4	0.3	0.4	4.3	0.4	29.8	10.8	0	0
11	0–20	15.4	8.4	1.70	2.6	0.1	0.2	2.0	0.3	0.5	0.3	0	0
	20–40	15.4	8.0	2.30	2.2	0.1	0.1	1.7	0.3	0.8	0.2	0	0
20	0–30	29.5	7.5	5.00	12.4	0.2	0.7	9.9	1.5	1.0	0.5	—	—
	30–60	29.3	7.4	3.00	7.1	0.2	0.1	6.5	1.1	1.3	0.3	—	—
	60–90	32.1	7.6	16.00	14.2	1.2	0.2	11.5	1.4	1.4	0.9	—	—
23	0–30	17.8	7.6	80.00	5.8	0.9	0.1	4.6	0.2	24.1	18.0	—	—
	30–60	18.8	7.6	50.00	10.4	0.5	0.2	9.1	0.7	11.5	5.6	—	—
	60–90	16.9	8.1	9.10	1.9	0.3	0.1	1.0	0.6	1.4	0.3	—	—
	0–20	23.3	7.5	55.00	8.5	0.4	0.8	6.4	0.9	17.5	0.3	—	—
	20–40	20.2	7.8	24.00	4.4	0.4	0.2	3.0	0.9	1.4	0.6	—	—
30	0–30	28.4	7.5	55.00	9.7	0.6	1.4	6.5	1.2	23.0	4.7	—	—
	30–60	24.2	7.7	55.00	8.5	0.6	0.6	5.9	1.3	17.0	11.1	—	—
32	0–30	23.1	8.2	32.00	5.5	0.5	0.9	3.4	0.7	9.5	4.8	—	—
	30–60	20.6	8.3	18.00	3.8	0.5	0.2	2.6	0.5	5.5	0.2	—	—
34	0–30	27.5	7.9	225.00	10.3	1.0	0.3	7.4	1.7	9.3	40.4	—	—
38	0–30	21.7	7.5	5.50	5.3	0.2	0.2	4.0	0.9	0.5	0.7	—	—
	30–60	18.8	8.4	5.00	3.6	0.2	0.1	2.7	0.7	0.9	0.3	—	—
48	0–30	19.2	8.2	8.00	2.4	0.2	0.1	1.9	0.3	1.0	0.9	—	—
49	30–60	19.1	8.1	10.00	1.8	0.2	0.1	1.3	0.3	5.0	1.2	—	—
60	0–30	18.6	8.0	95.00	1.9	0.3	0.0	1.1	0.3	16.0	6.0	—	—
61	30–60	18.6	7.5	115.00	1.6	0.1	0.1	1.5	0.5	8.5	2.1	—	—

Table 2.

Chemical analysis of the soils of the arid northern coastal zone 2. Chimbote projected irrigation area (hitherto unirrigated desert soils)

Sample No.	Depth cm.	pH	Electrical conductivity mmhos./cm.	Cation exchange capacity me./100 g	Exchangeable-cations me./100 g.				Saturation extract determinations							
									Cations me./l.				Anions me./l.			
					Na^+	K^+	Ca^{2+}	Mg^{2+}	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-
135	0 — 30	8.1	8.63	2.2	0.1	0.4	0.8	0.9	55.5	2.2	38.5	7.0	55.5	47.5	0	0.7
138	30 — 72	8.3	9.65	7.2	2.0	0.5	0.0	0.7	134.0	2.8	34.0	7.0	134.0	43.3	0	0.5
143	72 — 104	8.2	13.20	2.3	1.1	0.3	0.9	0.8	95.0	1.8	38.0	13.0	105.0	37.3	0	0.5
145	104 — 119	7.9	40.64	6.4	2.1	0.7	2.5	0.8	342.0	3.5	78.0	28.0	395.0	46.2	0	0.3
240	0 — 30	7.0	48.26	16.2	0.8	4.8	9.4	1.2	298.0	1.2	231.0	40.0	545.0	0.0	0	0.9
272	30 — 60	7.0	49.40	17.6	3.0	0.5	12.6	1.4	226.0	3.2	350.0	110.0	523.0	113.4	0	0.8
290	60 — 125	7.1	21.59	5.4	0.9	0.1	4.0	0.4	60.0	0.2	141.0	59.0	175.0	5.2	0	1.0
261	0 — 30	8.3	5.20	2.4	0.5	0.3	1.2	0.4	24.4	1.3	35.0	5.0	24.5	40.6	0	0.4
282	30 — 60	9.0	3.27	1.7	0.7	0.3	0.3	0.4	15.6	0.9	19.6	6.4	5.5	35.8	0	1.0
296	60 — 100	9.2	8.38	1.4	0.8	0.2	0.2	0.2	72.0	1.4	11.0	3.0	55.0	30.3	0	1.1

Table 3.

Chemical analysis of the soils of the central arid coast 1. Acari "Pampas" (Santa Terresita)

Sample No.	pH	Electrical conductivity mmhos./cm.	Cation exchange capacity me./100 g	Exchangeable-cations me./100 g.				Saturation extract determinations							
								Cations me./l.				Anions me./l.			
				Na^+	K^+	Ca^{2+}	Mg^{2+}	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-
406	8.4	61.00	13.5	8.6	1.1	0.6	3.2	510	6.0	137	67	630	58	0	4.2
407	8.8	19.06	11.0	2.9	1.1	5.5	1.6	186	1.6	53	4	161	75	0	4.0
408	8.9	103.70	10.5	6.3	1.2	1.8	1.2	1380	10.0	110	150	1400	233	0	7.0
409	8.9	22.26	8.6	5.9	0.5	1.0	1.3	222	1.2	39	16	181	86	0	6.4
410	8.7	63.28	9.4	1.3	1.5	5.4	1.2	720	9.0	70	75	710	155	0	5.0

Table 4.

Chemical analysis of the soils of the south arid coast 1. Tacna "Pampas" (La Yarada)

Sample No.	pH	Electrical conductivity mmhos./cm.	Cation exchange capacity me./100 g	Exchangeable-cations me./100 g.				Saturation extract determinations							
								Cations me./l.				Anions me./l.			
				Na^+	K^+	Ca^{2+}	Mg^{2+}	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-
504	7.6	100.06	8.1	4.9	0.6	0.2	2.4	1030	9	400	350	1700	81	0	3
505	7.4	187.62	8.0	4.6	0.9	1.8	1.7	3940	18	490	590	4900	85	0	3
506	7.6	109.44	9.6	3.2	1.6	2.3	2.6	830	18	480	820	2050	88	0	1
507	7.0	154.78	10.8	6.4	0.6	0.8	3.0	2450	16	550	750	3440	319	0	2
508	7.4	60.98	4.3	0.9	0.9	1.2	1.4	310	8	250	380	880	59	0	2
509	7.5	26.58	3.9	1.5	0.1	0.5	1.9	144	7	125	139	390	20	0	1
510	8.2	75.05	11.6	1.0	2.3	4.8	3.5	500	9	100	150	640	114	0	2
511	7.4	162.60	10.8	6.9	2.2	0.7	1.0	2120	14	1130	960	3050	1169	0	2
512	7.8	137.58	14.4	7.0	1.1	3.5	2.5	2600	13	450	680	3050	688	0	2
513	7.3	32.83	21.8	3.6	1.4	13.1	3.7	1275	54	222	133	520	1154	0	2
514	6.9	128.21	12.6	5.4	1.0	2.5	3.8	2920	36	410	580	3300	595	0	1
515	8.2	5.94	8.4	1.9	1.1	2.8	2.6	33	1	40	9	50	29	0	2

Table 5.

Chemical analysis of soils from alluvial region of north coast 1. Piura Valley (Cumbibira and San Miguel Farms)

Sample No.	Depth cm.	pH	Electrical conductivity mmhos./cm.	Cation exchange capacity me./100 g	Exchangeable-cations me./100 g.				Saturation extract determinations							
									Cations me./l.				Anions me./l.			
					Na^+	K^+	Ca_4^{2+}	Mg_4^{2+}	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl_1^-	SO_4^{2+}	CO_3^{2-}	HCO_3^-
356	0—30	8.4	5.21	4.9	1.0	0.4	2.3	1.2	32.6	0.9	16.0	9.0	28.5	23.9	0	1.0
357	30—60	8.9	5.35	7.8	2.0	0.1	3.6	2.1	46.5	0.4	8.5	5.0	26.5	31.4	0	1.5
358	0—30	8.0	12.89	11.1	4.0	0.6	4.1	2.4	63.0	1.6	60.0	23.0	107.5	33.6	0	1.5
359	30—60	8.4	1.37	8.1	2.8	0.6	2.9	1.8	5.2	0.6	5.5	4.0	2.3	7.5	0	1.5
360	0—30	8.7	4.65	7.2	1.9	0.4	3.3	1.7	24.0	0.7	8.5	5.5	14.8	18.0	0	1.0
361	30—60	8.8	1.54	5.3	0.8	0.4	3.2	0.9	7.2	0.4	6.0	4.0	4.8	7.8	0	1.0

Table 6.

Chemical analysis of soils from alluival regions of central coast 1. Huaura Valley (Rupuia Farm)

Sample No.	pH	Electrical conductivity mmhos./cm.	Cation exchange capacity me./100 g	Exchangeable-cations me./100 g.				Saturation extract determinations							
								Cations me./l.				Anions me./l.			
				Na^+	K^+	Ca^{2+}	Mg^{2+}	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-
378	7.8	14.22	10.7	2.4	1.7	3.5	2.0	54	8.6	86	34	82	10.5	0	0.5
380	8.1	13.71	10.9	2.5	1.2	3.1	3.8	32	23.6	70	101	420	14.6	0	2.0
381	8.1	10.92	11.4	3.1	0.9	3.3	4.2	40	2.3	69	22	68	14.2	0	1.1
382	7.8	54.61	15.2	4.3	2.8	0.7	3.6	460	46.0	140	160	560	43.3	0	2.7
383	8.0	29.85	10.2	2.1	1.3	2.8	4.0	204	8.4	105	61	122	145.0	0	0.9
384	8.3	9.39	9.9	2.8	0.4	3.5	3.2	60	1.2	50	8	59	10.0	0	1.4
385	8.1	10.67	8.6	1.8	0.5	3.8	2.5	37	1.1	66	25	60	17.8	0	1.0
386	8.1	13.34	8.9	2.1	0.7	4.1	2.1	42	1.7	94	26	70	13.0	0	0.7
387	8.1	14.73	11.0	1.9	0.6	4.3	4.2	46	1.7	107	33	59	27.9	0	0.8

Table 7.

Numbers and percentages of soil samples of Table 1—6.

Location	Non-Saline non-alkaline soils		Saline Soils		Non-Saline Alkaline Soils		Saline-alkaline soils		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
A. *Non-irrigated desert soils*										
Chao — Viru	4	17.5	15	65	0	0	4	17.5	23	100
Chimbote	0	0	2	20	2	20	6	60	10	100
Acari	0	0	0	0	0	0	5	100	5	100
Tacna	0	0	1	0.9	0	0	11	90.1	12	100
B. *Irrigated alluvial soils*										
Piura	0	0	0	0	0	0	6	100	6	100
Huaura	0	0	0	0	0	0	6	100	6	100
% Total	4	6.51	18	29.03	2	3.26	38	61.20	62	100

Objective of the investigation

The object of the study being reported was to survey and record the occurrence and nature of saline and alkali soils in the Peruvian coastal zone.

Survey of salinity and alkalinity in soils

Field trips were made to different areas of the coastal zone where both non irrigated (dry) and irrigated lands were studied. Since there was no evidence of profile development in any of the soils the soil-samples were divided arbitrarily in accordance with the different layers encountered in the profile. Each sample represents a condition noted at the time of sampling. The soils were separated into two groups.

1. *Soils of desert origin*

Extensive areas of level to gently sloping and occasionally rolling land composed of unconsolidated marine sediments such as stratified clays, silts, sands and gravel are found associated with desert lithosols along the entire coast. Some of the sedimentary layers are salty, gypsiferous and/or calcareous. Indurated salt crusts often as much as 1 metre in thickness are common. Some of the more level and extensive desert regosols are under irrigation, and several new irrigation projects on these soils are proposed.

The soils correspond to the World Soil Group of Regosols, or Gray Desert Soils. The elevation varies from 0 to 1,000 metres above sea-level. The water table is always at or below 1.5 metres below ground level. The predominant texture is sand or loamy sand, and the organic-matter content is always less than 1%.

Chemical analyses for these non-irrigated (desert) soils are presented in Tables 1—4.

2. *Alluvial soils*

The most important agricultural soils of Peru are those of alluvial origin, which are of high potential productivity and form the basis of the intensive agriculture of this region and amount to about 500,000 hectares.

The alluvial soils are formed by about 52 rivers which flow westward from the Andes, and about half of which are perennial. The soils are not uniform in texture, because deposition has taken place under varying conditions of topography and rate of flow. They are of variable depth, in general neutral to alkaline in reaction and in many areas gypsum, soluble salts and calcium carbonate are present. The organic matter content is low, ranging from less than 0.5% to about 2%.

Chemical analyses for these soils are given in Tables 5 and 6.

Results

The survey of the nature of the saline and alkali soils in the different regions of Peru is by no means exhaustive and is best described as a brief reconnaissance survey in order to obtain some of the more important information about the nature of these soils.

Sixty-four soil samples were analysed, with results shown in Tables 1 to 6 and in accordance with the classification suggested by the U. S. Salinity Laboratory, Riverside, California. The percentage of the samples which fall in each class is indicated in Table 7.

Conclusions from these samples

1. All the irrigated alluvial soils sampled are saline-alkaline;
2. only 6.51% of the non-irrigated desert soils sampled are unaffected by salinity or alkalinity;
3. 9.03% of the non-irrigated desert soils are inherently saline;
4. alkaline soils represent only 3.26% of the total and are found mainly in the northern part of the zone;
5. 61.2% of all the soils sampled are saline-alkaline.

Summary

This survey was in the nature of a reconnaissance in order to elicit some of the more important information about the nature of these soils in fairly general terms. The following is the result of the survey:

Non-saline, non-alkaline soils	6.51%
Saline soils	29.03%
Non-saline alkali soils	3.26%
Saline-alkali soils	61.20%
	100.00%

The formation of such soils may be attributed to one or more factors: arid conditions, extreme heat and evaporation, principally in summer, high water-table and poor drainage, lowlying topography, intensive and often inefficient irrigation practices, and the pedogenic process involved in the formation of the original soil.

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Природа приморских засоленных почв (солончаков и солонцов) в Перу

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Резюме

Перуанская приморская зона представляет собой узкую полосу, проходящую по всей длине страны, и которая граничит с севера — Эквадором, с юга — Чили, с востока — предгорьем западной части Анд и с запада — Тихим Океаном.

Длина этой приморской зоны приблизительно 2000 км ширина изменяется от нескольких километров [5] на юге, до свыше 100 км на севере. Приморская зона распола-

гается между 3 и 18 градусами южной широты и 70 и 82 градусами западной долготы. Площадь её достигает 145 000 квадратных километров, что составляет 11,3% всей территории страны. Однако из этой площади всего лишь 10% пригодных для сельскохозяйственного производства земель, ибо большая часть этой территории имеет пустынный характер. На этой территории живёт 28,9% населения Перу. Густота населения — 21,47 человек на, 1 квадратный километр. Экономическое значение приморской зоны чрезвычайно велико, что объясняется возделыванием на этой территории важнейших экспортных растений как, например: хлопка, сахарного тростника, риса, разных фруктов и т. д.

Годовое количество осадков на средней и южной частях Приморья чрезмерно малое, еле достигающее 50 мм в год. Однако в северной части Приморья выпадает побольше осадков, годовое количество которых достигает 300 мм. Средняя годовая температура колеблется от 16 до 24,3 градусов Цельсия.

Количество осадков настолько малое, что непосредственного влияния не может оказывать на сельскохозяйственное производство, и, естественно, не может быть и речи о сколько-нибудь заметном выщелачивании этих почв.

Геоморфологическое строение приморской зоны представляет особый интерес, потому что эта территория является «taclazos marinos», то есть низко лежащая приморская равнина на средней и северной частях Приморья и пампасами в южной части страны, в силу того, что территория имеет морское происхождение, поэтому почвы содержат большое количество солей.

В последние годы содержание солей в почвах этой территории увеличилось. Подобным процессом охвачено 25—30% территории, в силу чего большие площади выпадают и становятся непригодными для сельскохозяйственного производства.

В генезисе этих почв принимало участие несколько факторов, в том числе сухость климата, высокие летние температуры, интенсивное испарение летом, низкое топографическое расположение местности, интенсивное, однако часто безэффективное, орошение, близкий уровень залегания грунтовых вод, слабая дренированность территории и т. д. Поэтому исследование, познание этих почв и классификация их на генетической основе весьма важно с точки зрения их мелиорации.

Данные полевых и лабораторных исследований почв перуанской приморской зоны показывают, что эти почвы почти без исключения являются или солончаками или солонцами или же представляют собой переходные (смешанные) типы.

В результате наших исследований установлено следующее процентное распределение разных типов засоленных почв:

Незасолённые и несолонцовые (нормальные) почвы	6,51%
Засоленные почвы (солончаки)	29,03%
Незасоленные солонцовые почвы (солонцы)	3,26%
Засоленные солонцовые почвы (солончак-солонец)	61,20%
	100,00%