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Release rates of alloy constituents from stainless steel

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Aim:

**To present a selection of results
related to possible environmental effects of stainless steel**



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Experimental

**Stainless steel
massive products**



**Ferritic
Austenitic
Duplex**



Synthetic Body Fluids



**Stainless steel
powder
particles**



Austenitic

Metal release rates

Natural and artificial rain



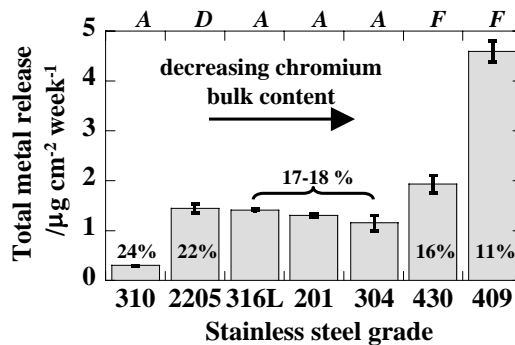


Why is it important to provide metal release data of alloy constituents from stainless steels?

- Stainless steels are used in a wide variety of areas and applications.
- Scarce or no data available on metal release rates of alloy constituents.
- Lack of understanding of differences between alloys and the pure metals.
- Knowledge gaps concerning potential environmental or health effects of alloy constituents released from stainless steel.



How does alloying influence the metal release rates?



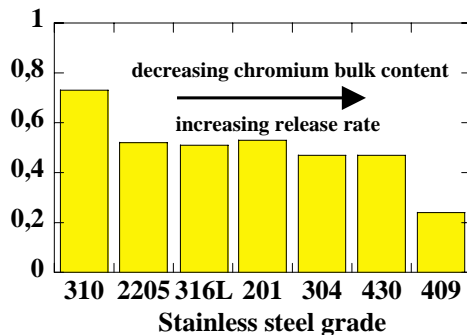
One-week exposure in artificial lysosomal fluid (ALF).

**Metal release rates decrease with increasing chromium bulk content:
409 >> 430 > 2205, 316L, 201, 304 > 310.**



How does alloying influence the metal release rates?

$Cr/(Cr+Fe)$
in passive film,
as obtained by
XPS

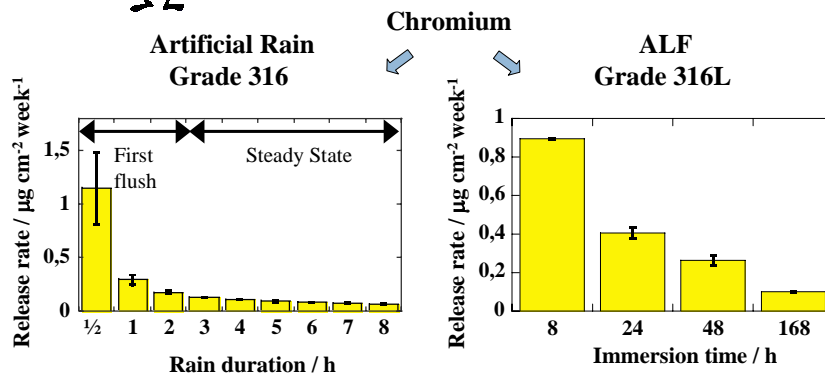


One-week
exposure in
ALF.

Total weekly metal release rates are related to the degree of alloying. Other factors such as surface finish, surface film thickness and composition, steel microstructure, and presence of defects also influence the release rate.



Is the metal release process of alloy constituents time-dependent?



Stainless steel exhibits a decrease in metal release rate with time of all alloy constituents in all fluids investigated.



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How much is one $\mu\text{g cm}^{-2}\text{ week}^{-1}$?



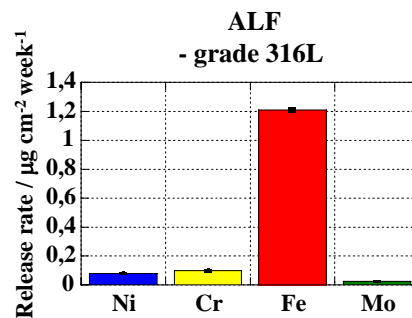
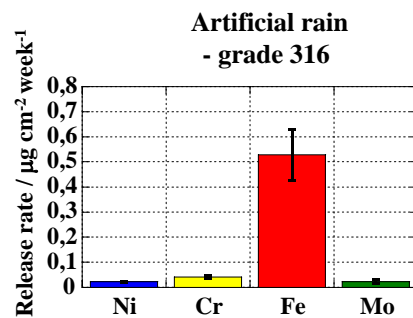
One $\mu\text{g cm}^{-2}\text{ week}^{-1}$ corresponds to one nanometer of stainless steel that is released every week, or one micrometer released every 20 years !



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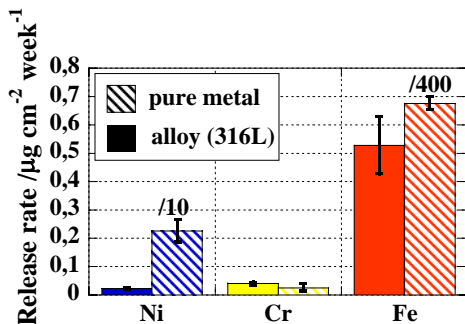
Is the release rate the same for all alloy constituents?



Iron is preferentially released compared to nickel, chromium and molybdenum from all grades, surface finishes and fluids investigated.

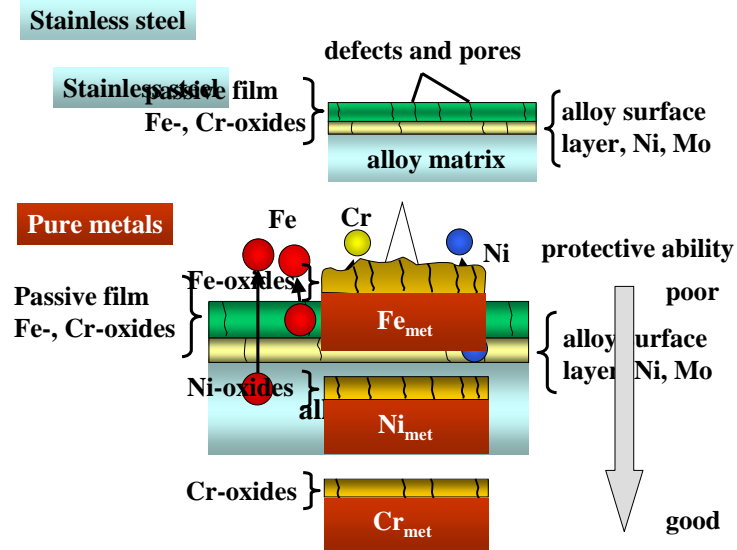


Are release rates of alloy constituents from stainless steels equal to release rates from the pure metals?

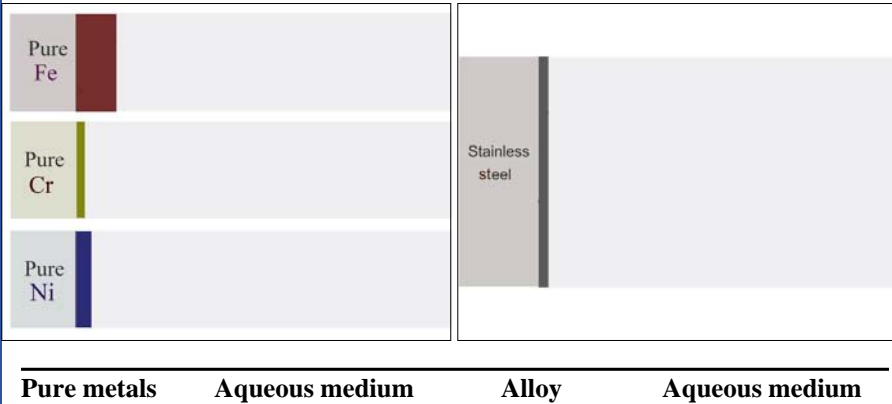


The presence of a chromium rich passive film on stainless steel reduces the release rates of iron and nickel compared to the pure metals. Similar release rates of chromium from stainless steels and the pure metal.

Schematics of release rate mechanisms



Metal release rates of alloy constituents from stainless steel compared to metal release rates from the pure metals



Metal concentrations in runoff rain water compared to WHO recommendations



Metal concentrations in runoff rain water (Stockholm):

- $\leq 1.2 \mu\text{g Cr L}^{-1}$
- $\leq 0.7 \mu\text{g Ni L}^{-1}$
- $\leq 15 \mu\text{g Fe L}^{-1}$

WHO recommendations for drinking water:

- $< 50 \mu\text{g Cr L}^{-1}$
- $< 20 \mu\text{g Ni L}^{-1}$
- $< 300 \mu\text{g Fe L}^{-1}$

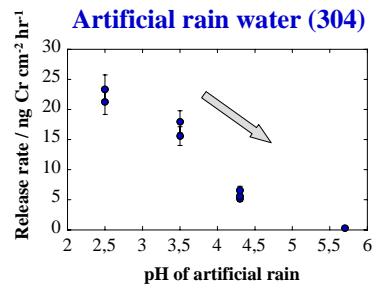


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Summary of release rates measured in different solutions

<u>Total release rate</u>	<u>$\mu\text{g cm}^{-2}\text{ week}^{-1}$</u>
Rain (pH 4.3)	0.61
ALF (pH 4.5)	1.3
Gamble's solution (pH 7.4)	0.075

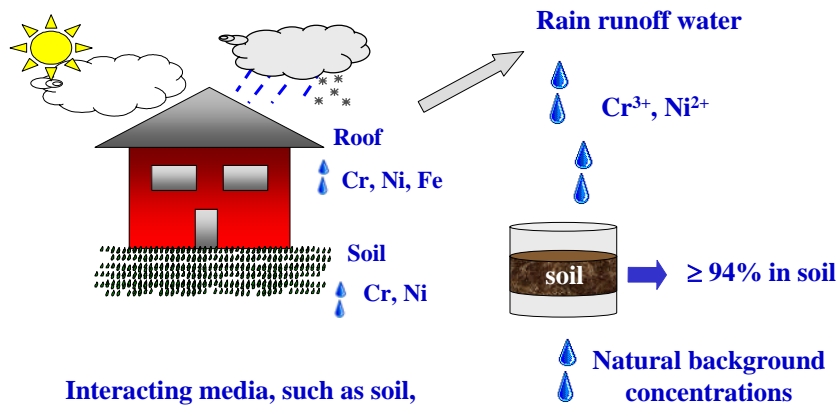
Release rates increase
with acidity of solution.



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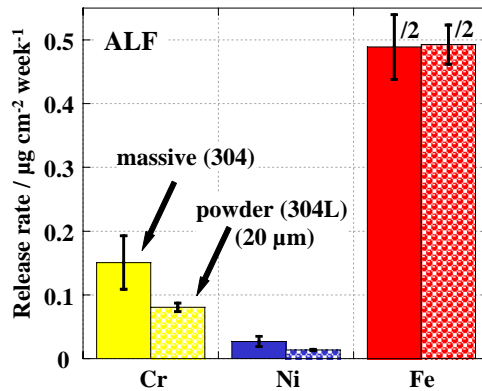
What happens with chromium and nickel in rain runoff water on contact with soil?



Interacting media, such as soil,
possess a strong ability to retain the metals.



Do small stainless steel powder particles exhibit different release rates than massive flat surfaces?



Our investigations so far do not suggest any significant differences



Concluding remarks

- Scarce or no data available on metal release rates of alloy constituents. *Metal release rate data are now available for a variety of solutions and stainless steel grades.*
- Lack of understanding of differences between alloys and the pure metals. *The release rates of iron and nickel from stainless steel are significantly lower than from the pure metals. Release rates of chromium from stainless steel and the pure metal are similar.*
- Knowledge gaps concerning potential environmental or health effects of released alloy constituents from stainless steel. *Total release rates from stainless steels are very low and generally decrease with increased chromium content in the steel.*



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Publications and on-going work

Experimental development

Publications in peer-reviewed literature

Reports

Conference proceedings

Academic theses

To be continued...



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