Application of Reaction Cell ICP/Ms for Improved Detection Limits for As and Se in Salt Impacted Water Samples

Presented by Gordon Nelson, AGAT Labs

AGAT Laboratories

Service Beyond Analysis

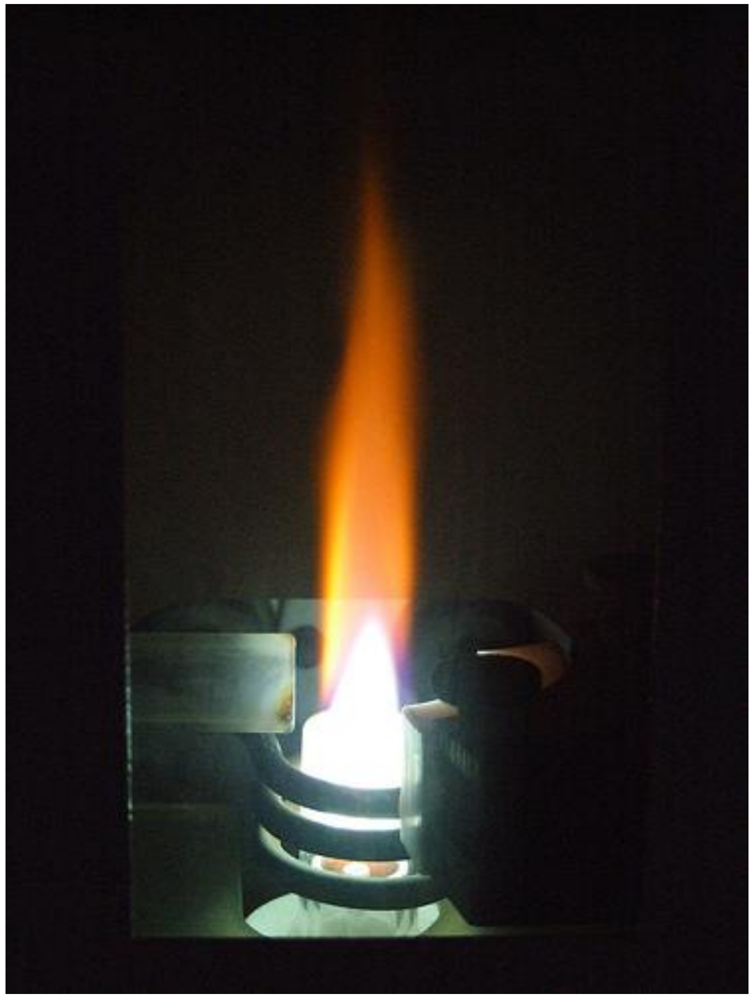
www.agatlabs.com

Reaction Cell ICP MS

- Overview of ICP technology
  - ICP : The plasma
  - ICP: Optical Emission
    - Interferences
  - ICP: Mass spectrometry
    - Interferences
  - Collision Cell Technology
- Overview of Reaction Cell Technology
  - Layout of cell
  - Control of reactions
  - Interferences removed
  - Salt impacted water analysis
- Next steps

The plasma

- Created by passing argon through a series of tubes that are wrapped by an RF coil.
- Energy supplied by the RF generator creates and contains the argon plasma.
- Plasma temperatures are around 6000-7000K
- Liquid droplets that contain the sample matrix and elements of interest are introduced into the plasma where they are instantly dried to a solid then converted to a gas.

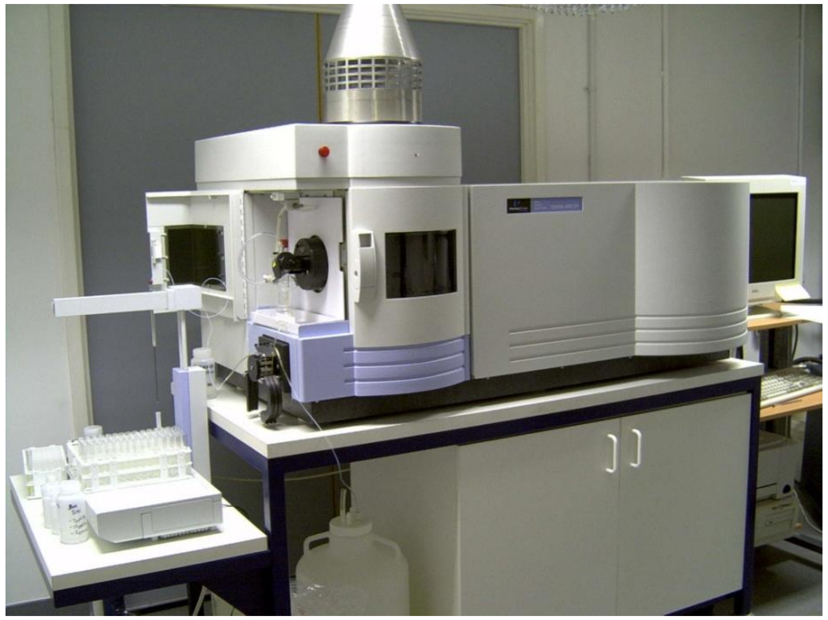


Optical Emission

- Energy from the plasma will excite electrons in the atoms causing a shift to a higher energy level.
- Electrons drop down to fill the lower orbital and a photon is released. Wavelength of light released is characteristic of the element.
- Interferences based on overlapping wavelengths; different orbital changes for elements.
- Detection simply by measuring intensity of light at various wavelengths.

ICP/OES - Limitations

- Subject to spectral interference
- Difficult to analyze more electronegative elements
- Detection limits not as good as ICPMS
  - Detection limits not suitable to As, Se, Sb



ICP/MS

- Same plasma created for MS as for optical.
- Elements in the plasma absorb more energy and release an electron. This forms a positively charged ion.
- For MS, identification and quantification is based on measuring the mass and quantity of the positive ions created.
- During this process other interactions are taking place that can form interferences.

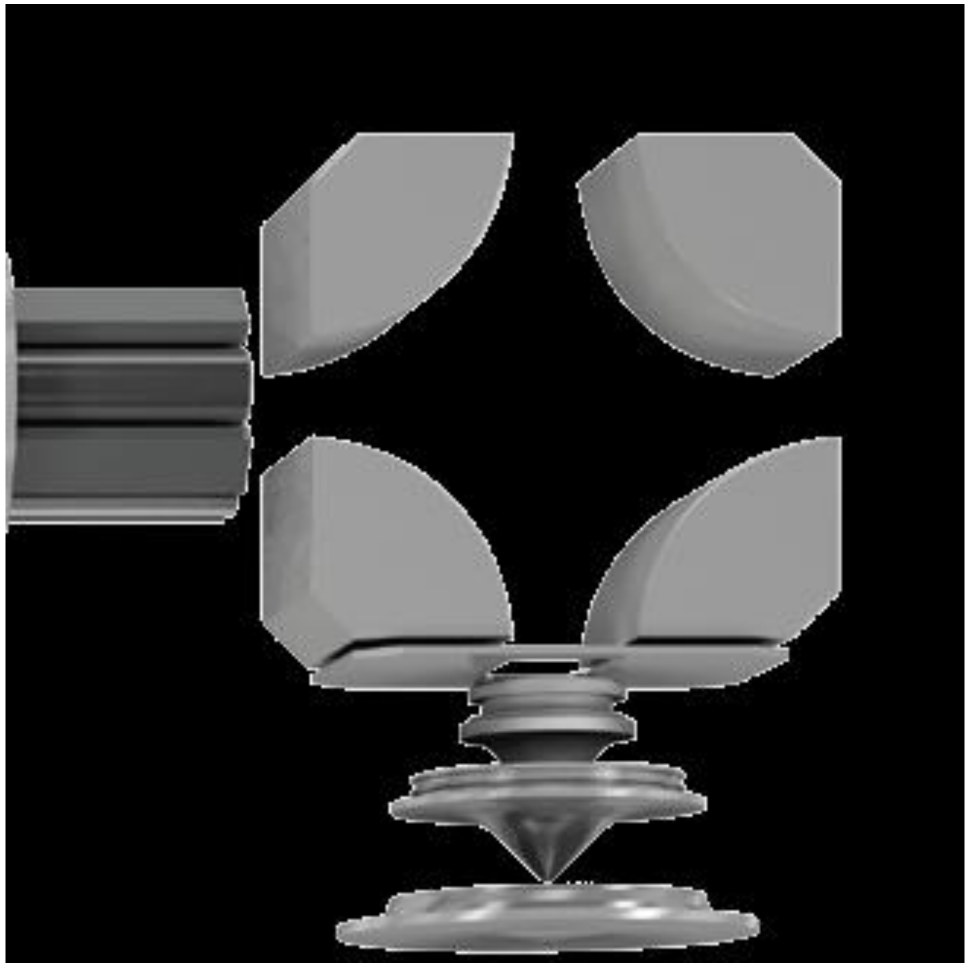
ICP MS : Interface

- Interface needed between the plasma and the ion focusing region of the MS
    - Plasma at high temps and atmospheric temperature
    - MS end at low vacuum and lower temperatures.
- Nexion system goes through a 3 cone system to reduce pressure.
    - Three cone system eliminates need for ion focusing lenses.

ICP/MS

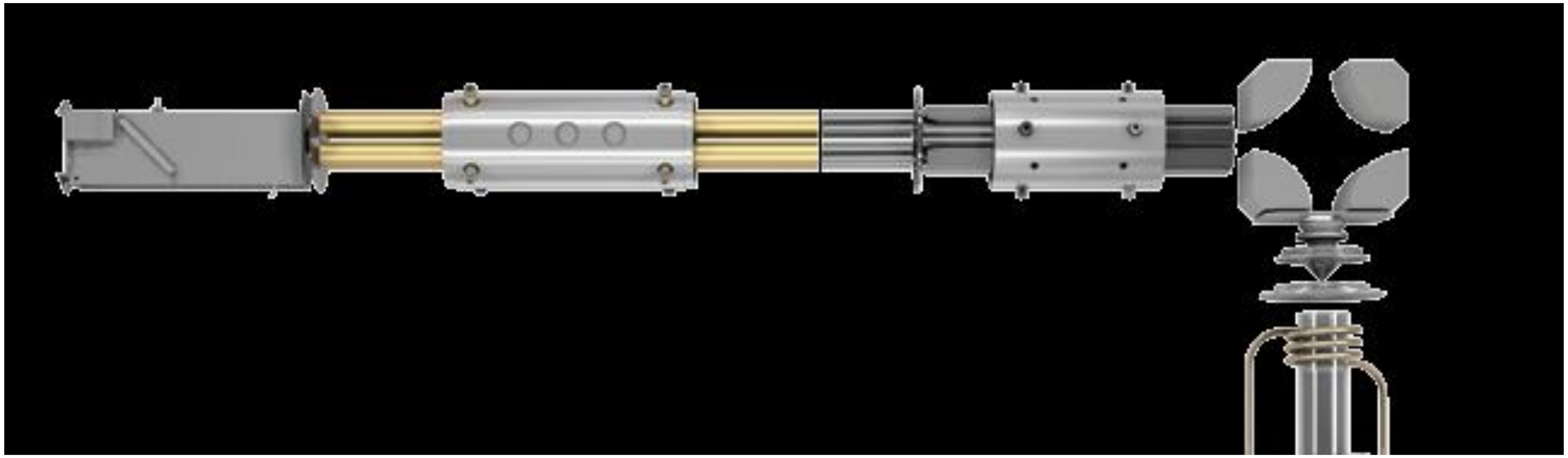
- The beam of material coming out contains:
  - Non-ionized material
  - Photons
  - Ions of interest
- Neutral material can collect on components reducing performance and cause drift.
- Photons might cause incorrect ion counts if they reach the detector.
- Nexion unit uses a quadrupole mass filter at a right angle to the beam.
- Positively charged ions deflected whereas the photons and neutrals aren’t affected and are removed from the beam.

Quadrupole Ion Deflector



ICP/MS

- After exiting the quadrupole deflector the ions enter the quadrupole mass filter.
- Quad works by adjusting voltages and Rf to allow certain mass/charge ratios to pass.
- Rapid scanning of different masses.
- Ions of a specific m/z are then counted in the electron multiplier.



Interferences

- Interferences are when something from the sample, the plasma or some combination carries a mass to charge ratio similar to what you are looking for.
- Argon is the gas used to generate the plasma and can combine with itself or other elements to form interferences.
- Oxygen from the sample matrix can combine with argon to form a polyatomic species ArO^+ with a mass of 56 amu
- One of the most prevalent isotopes for Iron is mass 56.
- ArO^+ will cause high background if we use mass 56 for iron,
  - Other isotopes can be used for iron but at lower intensity and therefore poorer detection limits.

ICP : Interferences

Potential Interfering Species	Analytes Impacted
$^{12}C^{15}N$, $^{12}C^{14}NH$	^{27}AL
^{38}ArH	^{39}K
^{40}Ar	^{40}Ca
$^{35}Cl^{16}O$	^{51}V
$^{35}Cl^{16}OH$	^{52}Cr
$^{36}Ar^{16}O$	^{52}Cr
$^{40}Ar^{12}C$	^{52}Cr
$^{38}Ar^{16}OH$	^{55}Mn
$^{40}Ar^{16}O$	^{56}Fe
$^{40}Ar^{16}OH$	^{57}Fe
$^{40}Ar^{35}Cl$	^{75}As
$^{40}Ar^{37}Cl$	^{77}Se
$^{40}Ar^{40}Ar$	^{80}Se

Collision Cell Technology

- Works on the idea that the polyatomic (i.e molecular) interferences are larger in size than the single elements.
- When both pass through a field of inert gas, the larger polyatomic will collide with more gas atoms than the smaller element.
- At the end of this process, the larger interfering compound has lower energy than the smaller element
- An energy barrier is placed at the exit of the cell that is adjusted accordingly and will only allow the higher energy elements to pass through.

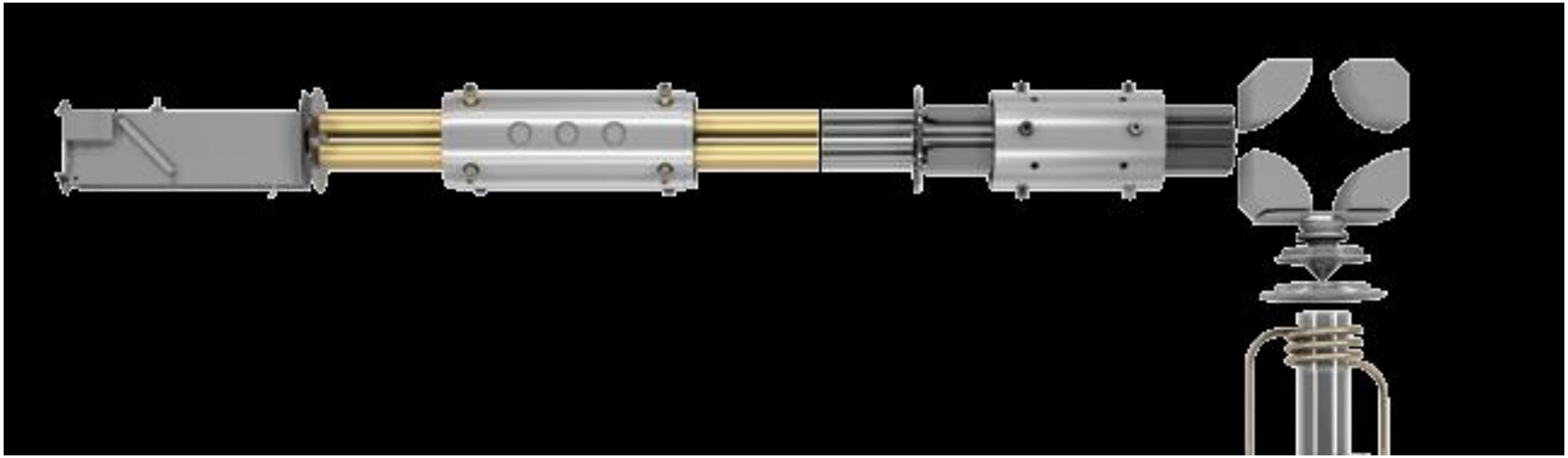
Collision Cell Technology

- Easy to set-up.
- Background is reduced
- Some reduction in target elements as well though.

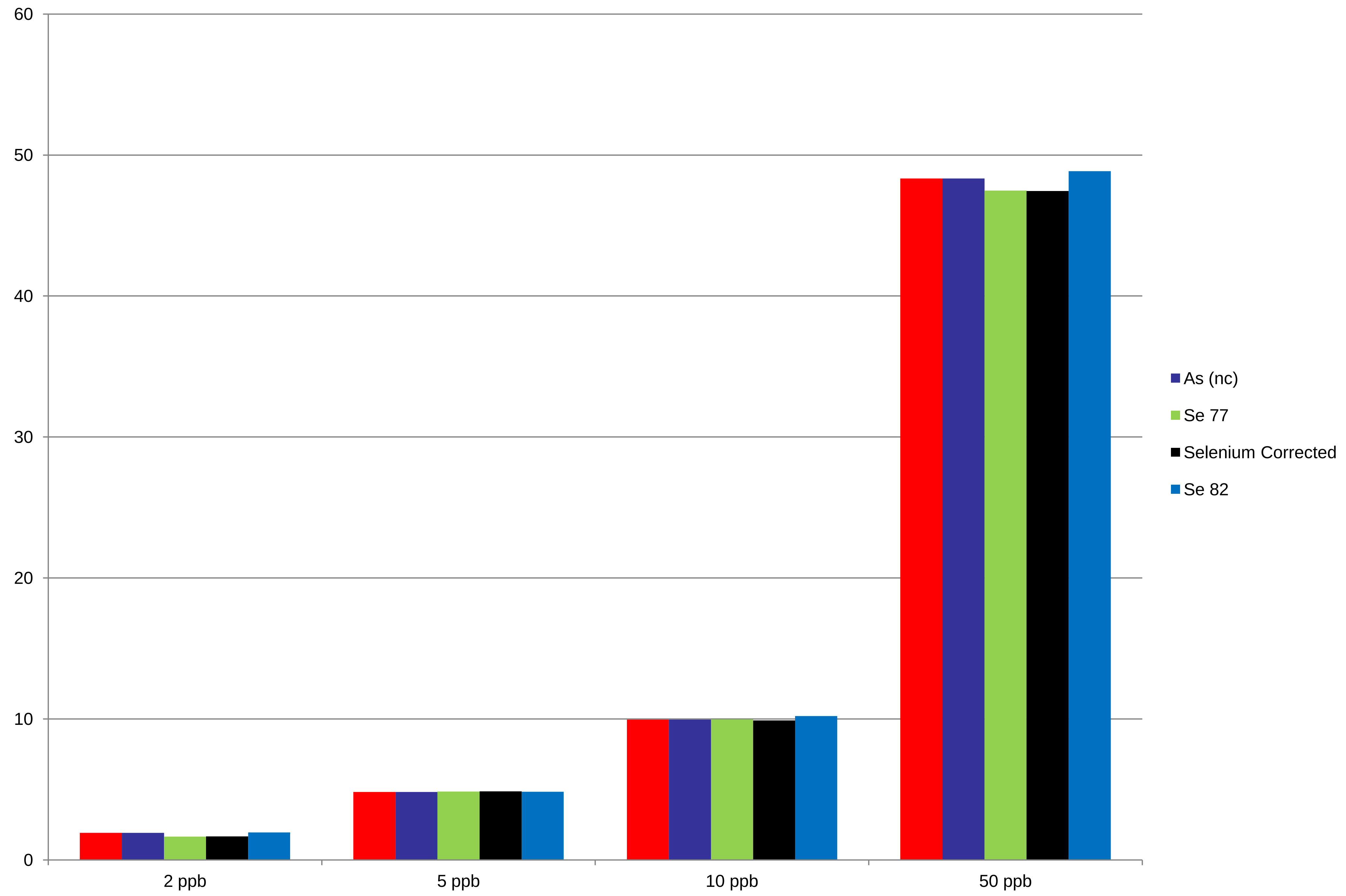
ICP : Overview of Reaction Cell Technology

- Reaction cell is based on true chemical reactions; not just kinetic energy reduction through collisions.
- More reactive gases are used; not just inert gases.
- The goal is to convert the interfering ion into a species that no longer interferes.
- Can also create new species with the target element that avoids the interfering ions.
- Reaction cell technology if properly set-up can reduce the interference without reducing the target element.
    - Preserves detection limit.
- Need to avoid creation of new interfering species.
- The DRC uses an active quadrupole to control reaction and prevent unwanted reactions.

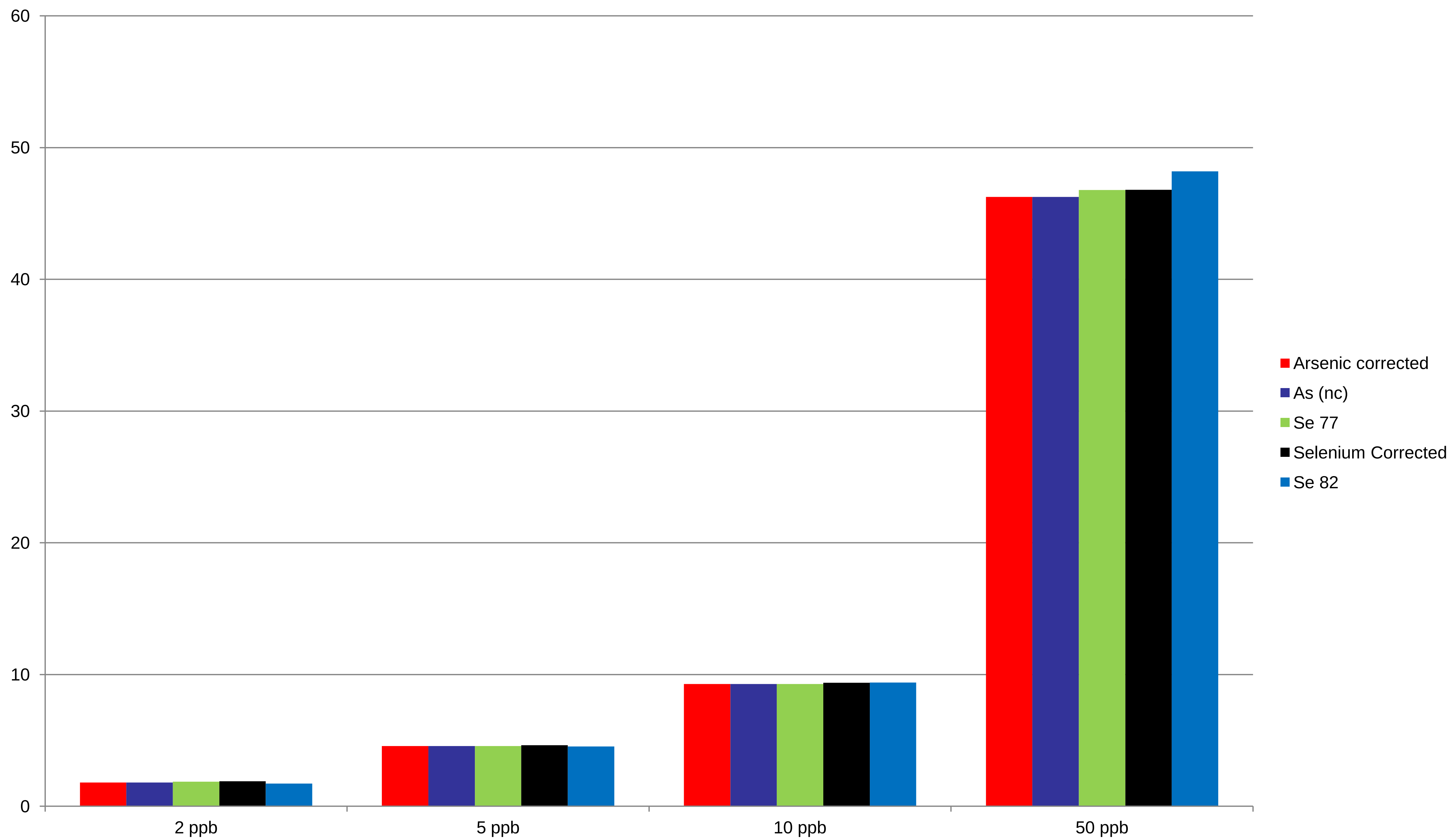
Layout of cell



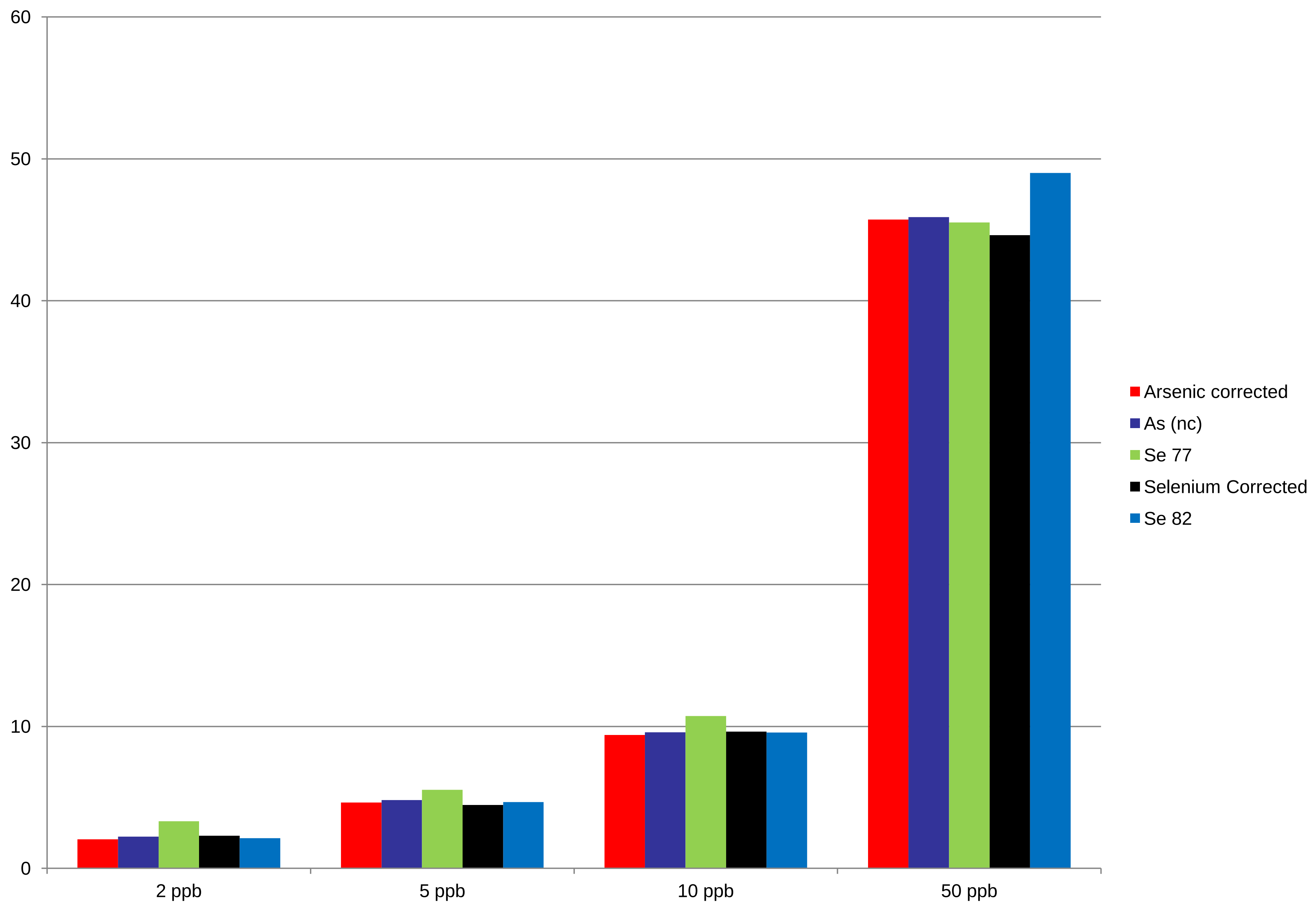
Std Mode - no added Chloride



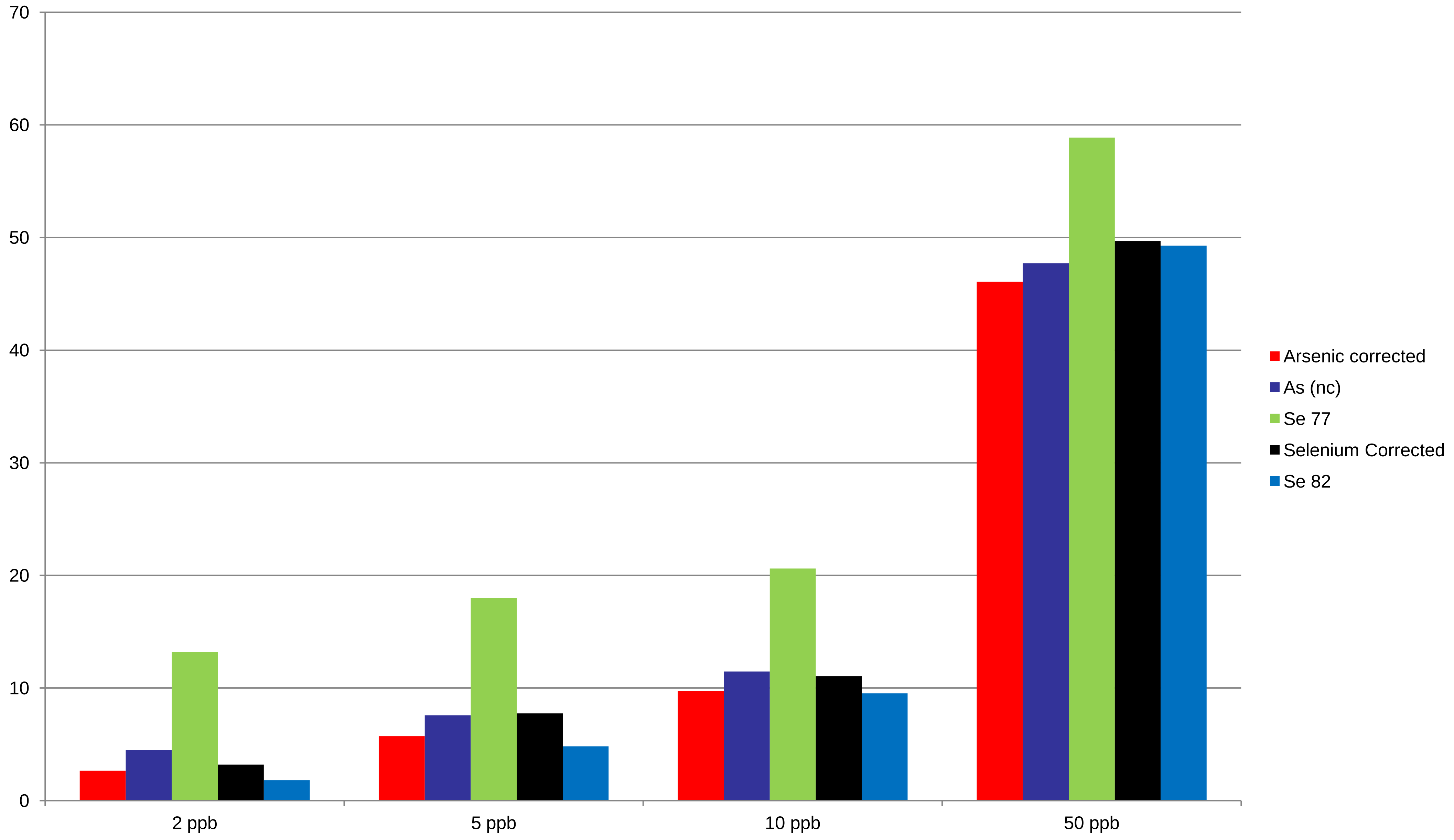
Std Mode - 1 ppm Chloride



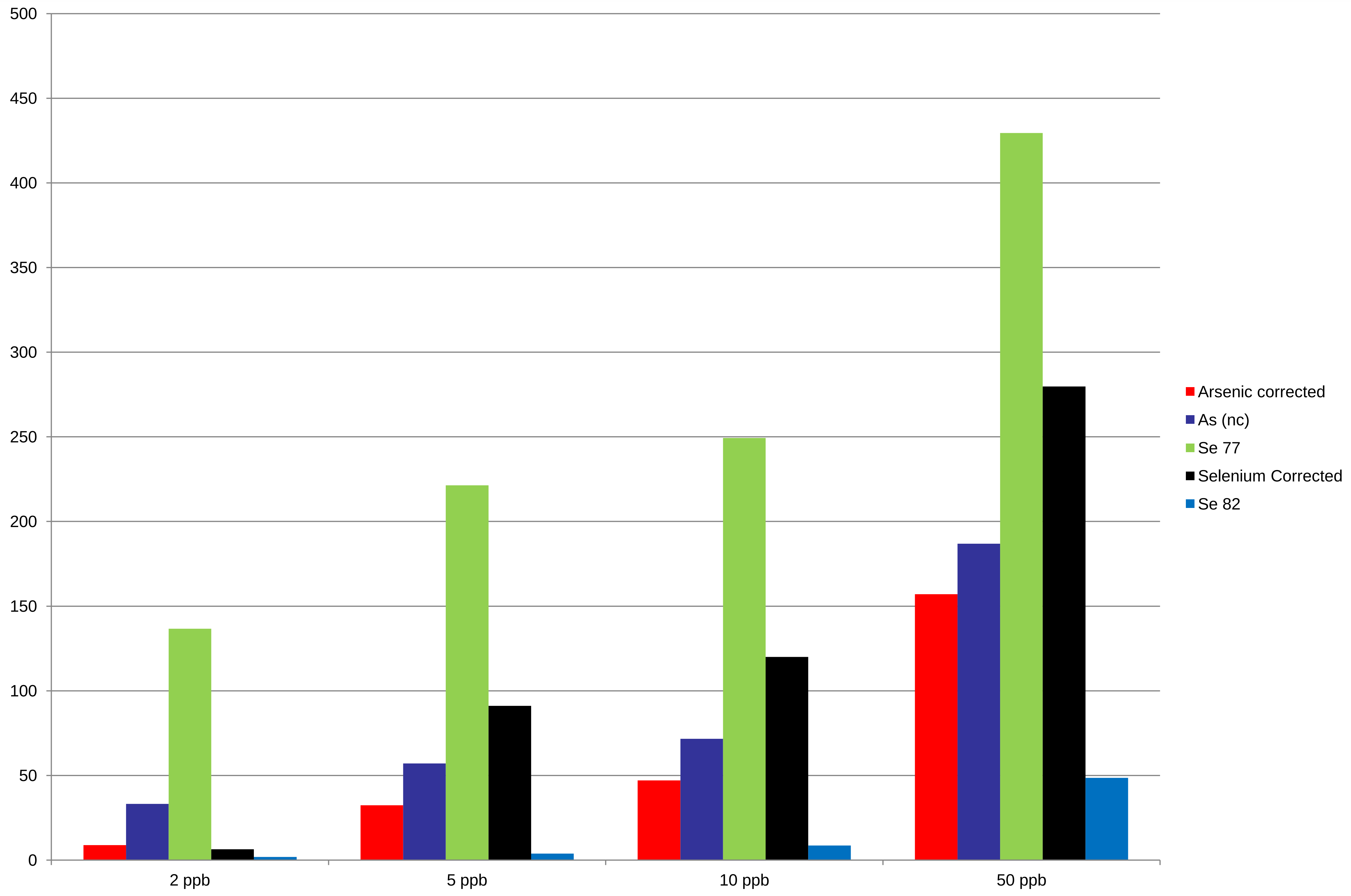
Std Mode: - 100 ppm Chloride



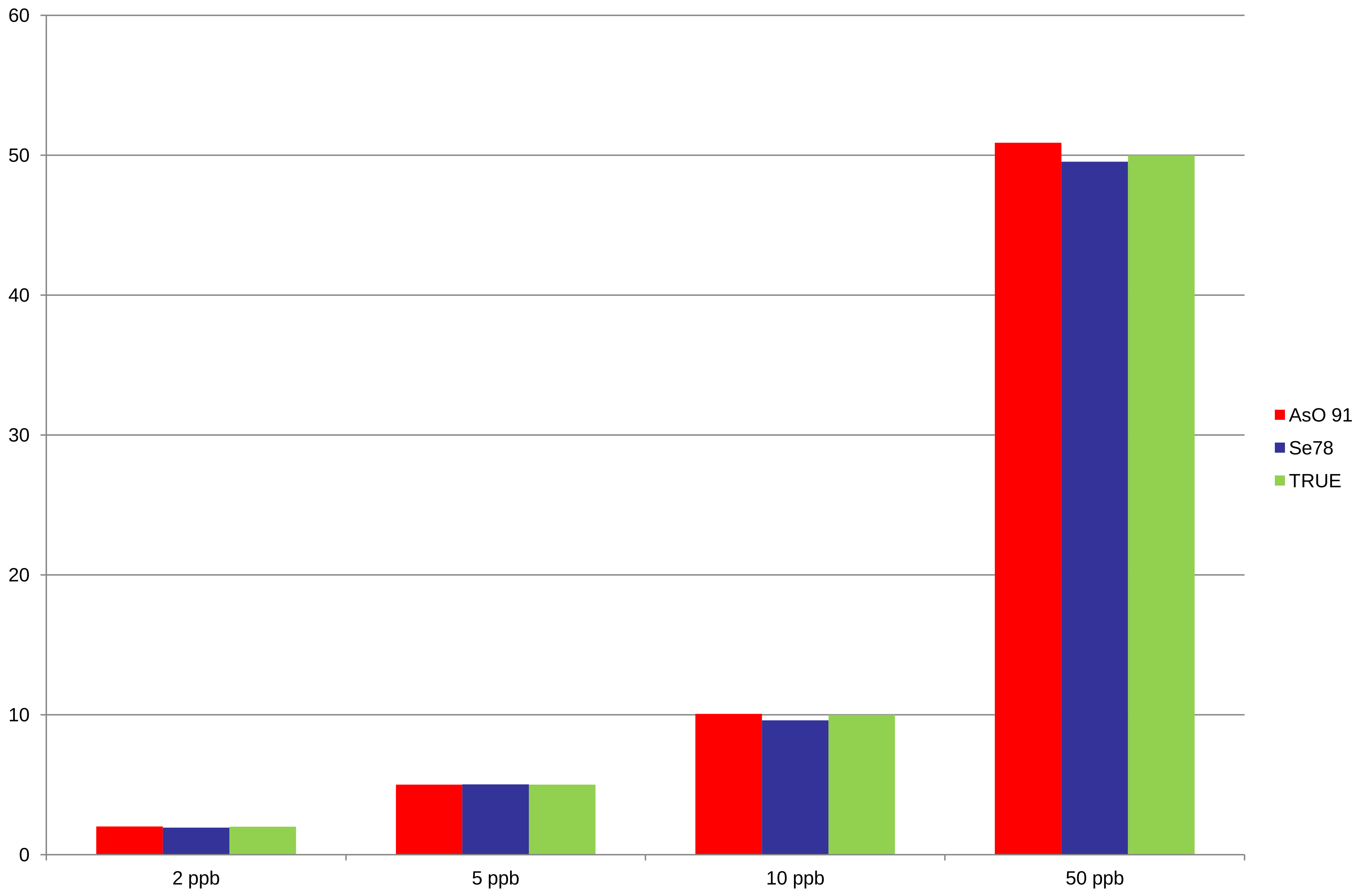
Std Mode - 1000 ppm Chloride



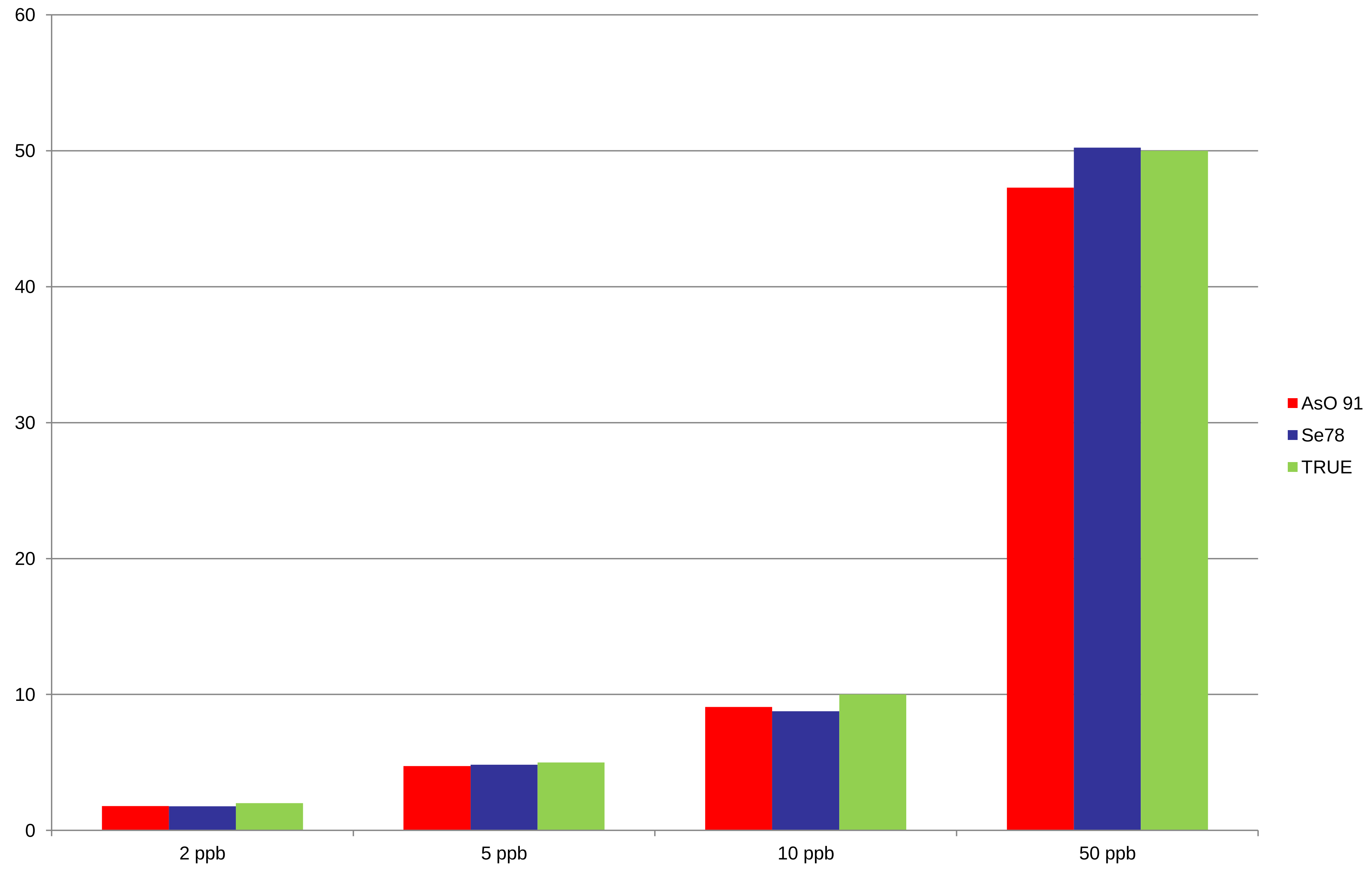
Std Mode- 10000 ppm Chloride



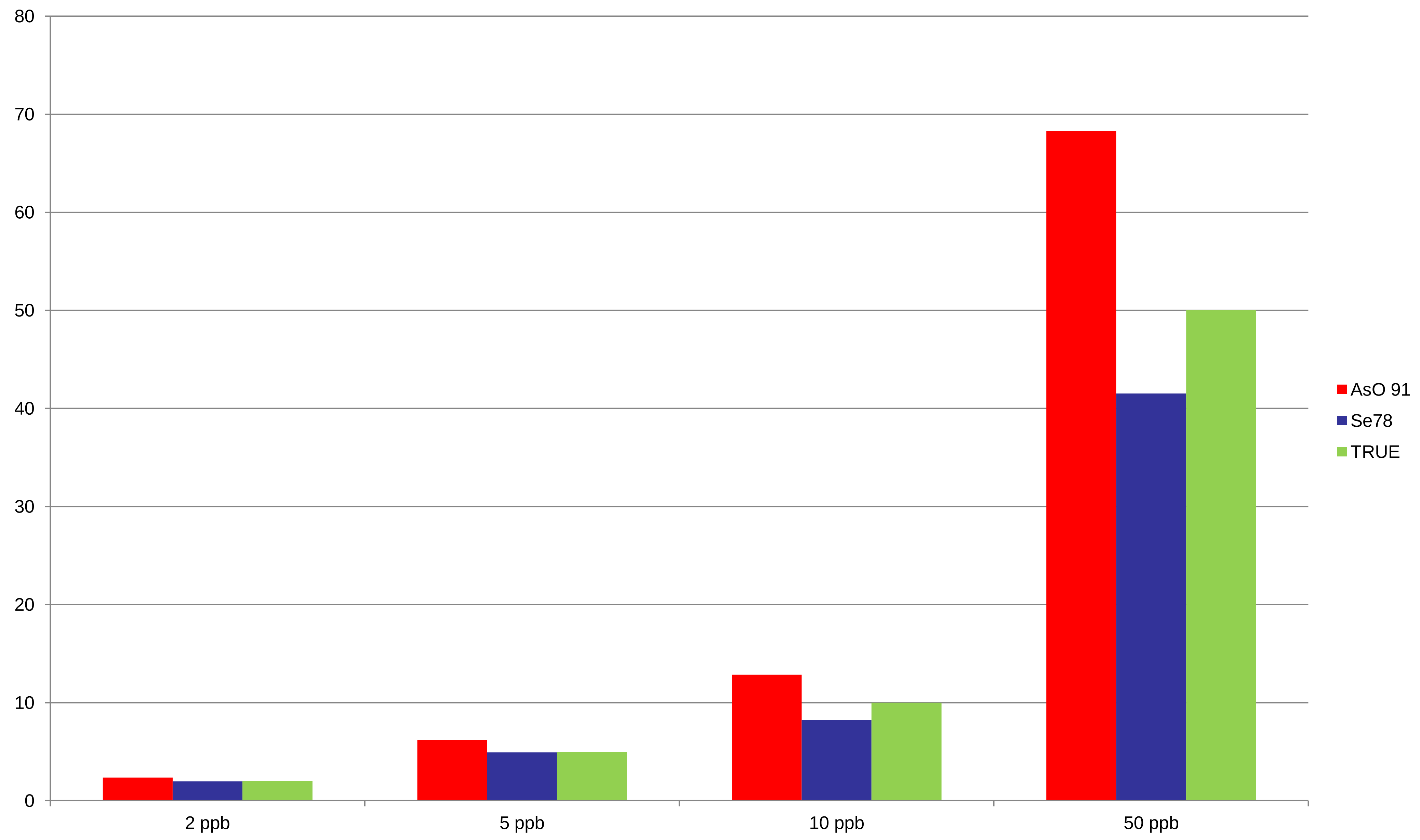
DRC Mode - no added Chloride



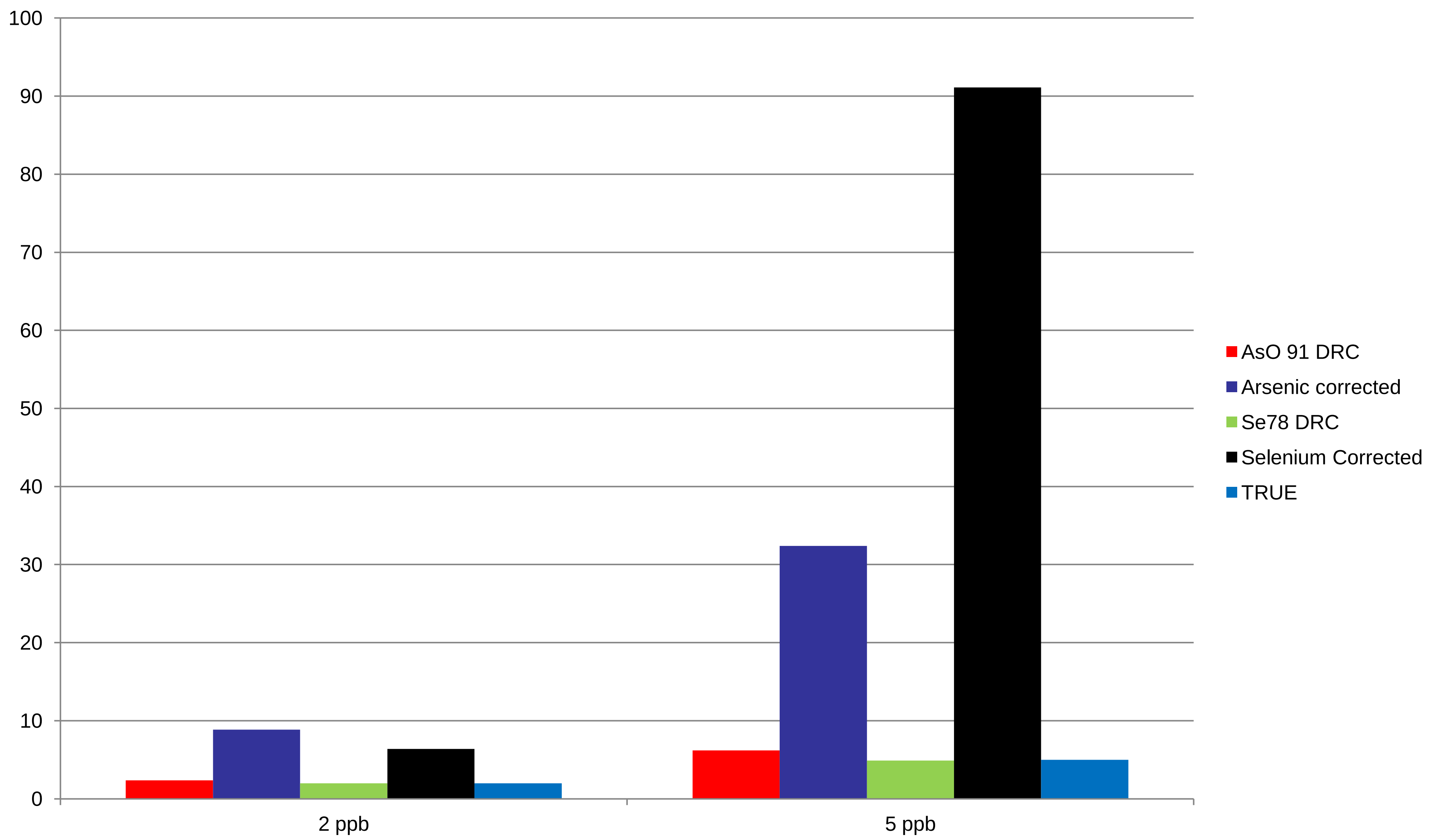
DRC Mode - 1000 ppm Chloride



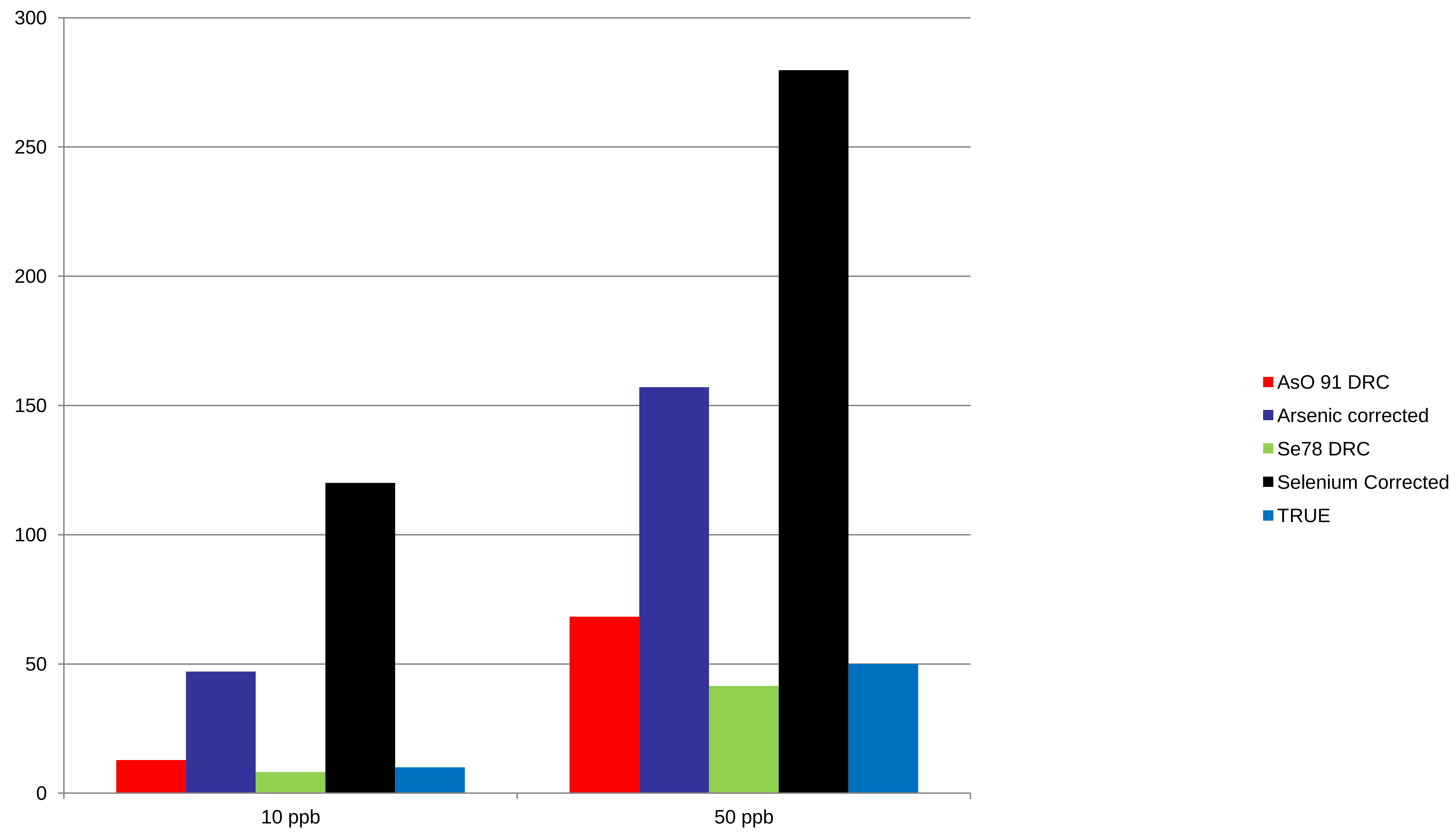
DRC Mode 10000 ppm Chloride



DRC vs Std mode: 1000 ppm Chloride



DRC vs Std mode 10000 ppm Chloride



Conclusions and Next Steps

- At chloride ion concentrations greater than 1000 ppm the DRC mode will yield more accurate data than standard operation mode ICP MS.
- Other flow-rates and other reactive gases could further improve the quantification of As in DRC mode.
- A full MV to be done after optimization of gases and flow settings.